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Eiffel's Experiments on Air-Resistance.

In another portion of this issue some interesting details are given of experiments that have been conducted by M. Eiffel, during the past three or four years, on the resistance offered by the air to plates let fall from the second stage of the famous tower erected by him in Paris. The conclusions reached have been issued as a memoir which, both from an engineering and purely scientific point of view, will be regarded as of the highest value.

Knowledge on the subject of air resistance is of importance from two points of view; that involved in a consideration of the action of air in motion upon stationary structures, and the other involved when opposite conditions prevail—the body being in motion and the air at rest. Little significance has, until recently, been attached to the latter aspect of the subject, but with the development of high speeds incident to modern methods of traction, the factor of air resistance has assumed a magnitude that is far from being negligible.

Unfortunately the formulæ involving co-efficients of resistance of bodies moving rapidly through the air, available for use by the engineer, have not shown that close agreement which engenders confidence, and the importance of M. Eiffel's research lies in the degree of accuracy reached in his results. The inconsistency of previous results related to K, that is, the co-efficient of resistance, in the Newtonian formula.

$$P_{90}^{\circ} = KV^2$$

(air pressure or resistance is approximately equal to the square of the velocity), the determination of which for different shaped surfaces at high velocities formed the object of Eiffel's investigation.

The values obtained by him for K are given in the article on another page, and while, as was to be expected, they are not identical for plates of different shape at the same speed, the variation shown is regular and appears both in connection with area and shape, and perimeter and area increasing with the former, the latter remaining constant in each case. For plates normal to the direction of motion, the same variation of K is apparent as the speed increases, although up to velocities of 130 ft. per sec. the Newtonian formula approximately applies. In the case of lattice work, K is shown to increase owing to the increased perimeter over a solid plate, and to still further increase where two lattice plates are superposed. A decrease of K occurs, however, when ordinary plates are superposed due

probably to increased suction effects on the back of the plate.

Brief reference may be made to the manner in which the experiments were carried out. The plate, of which the resistance was to be determined, was attached to an apparatus free to slide down a vertically stretched wire, the resistance being measured by springs, the deflection of which was recorded on a smoked cylinder. The latter was caused to revolve at a speed proportional to the fall, and waves corresponding to the vibration of a tuning fork, and recorded on the drum provided the time factor necessary to complete the data.

M. Eiffel's labours have removed much of the uncertainty which surrounded the question of air resistance and the data he has given us may be applied in design with truth and precision appearing in the results. The ground has by no means been covered, however, and a further research is promised by the same investigator which we hope may be as richly productive of good results as from that just concluded.

The Franco-British Exhibition.

It was hardly to be expected that the Franco-British Exhibition, having in view its international character, would be complete at the time of the official opening by the Prince and Princess of Wales. Much progress has, however, been made during the weeks that have intervened, and most of the exhibits should by this time be in the buildings, if not staged, and the final touches given to grounds and decorations.

The Machinery Hall, as explained in our January issue, covers an area of about 6½ acres, and consists of two main buildings, joined together at the south end by a building of similar construction, the whole forming a U-shaped building in plan. Each side building is 661 ft. long by 310 ft. wide. The machinery exhibits on the British side are, at the time of writing, fairly complete, although the majority in the French section still await erection.

As we propose to deal with the more important exhibits separately and in detail later, it will suffice to mention that the main interest attaches perhaps to the machine tool and gas engine sections, but the steam exhibits are hardly representative of so important a branch of engineering. Shipping companies are well to the fore, which cannot, unfortunately, be said of the railways, who limit their exhibits to models of rolling stock, permanent way sections, and maps. Locomotives, there are none. As far as exhibits go, electricity on the British side appears to be under a cloud. Only at the eleventh hour did the London Supply Companies come forward and arrange for a joint exhibit, which, being limited to the domestic application of electricity, does little more than save the industry from oblivion. This is somewhat compensated for, however, by the part that electricity plays in the illumination of the buildings and grounds, the magnificent effect of which is solely due to the agency employed.

Iron and steel are well represented, a noteworthy feature being the collective exhibit illustrating the British pig-iron industry, in which typical specimens of iron trade products are appropriately arranged with statistical and other diagrams, forming a display of better educational and commercial value than could perhaps have been achieved by individual firms. We shall deal with individual exhibits in future notices.

Ferro-Concrete Lighthouse, One Fathom Bank, Straits of Malacca.

By JOHN CRAIG.

The following is a unique application of ferro-concrete construction, a method which, although not so extensively adopted in this country as on the Continent and America, is rapidly advancing in popularity.

THIS lighthouse is situated in the Straits of Malacca about fifteen miles west of the coast line and about half a mile east of the shallowest part of the bank, in three fathoms of water, Latitude N. 2 deg. 53 min., Longitude E. 10 deg., which, for some years up to 1874, was marked by a lightship, this being replaced by a screw pile lighthouse having its focal plane 55 ft. above high water level, exhibiting a white light with a flash every minute. This lighthouse has, in turn, been replaced by the newly constructed ferro-concrete lighthouse, which the writer believes is the first one of this special construction erected in the open sea.

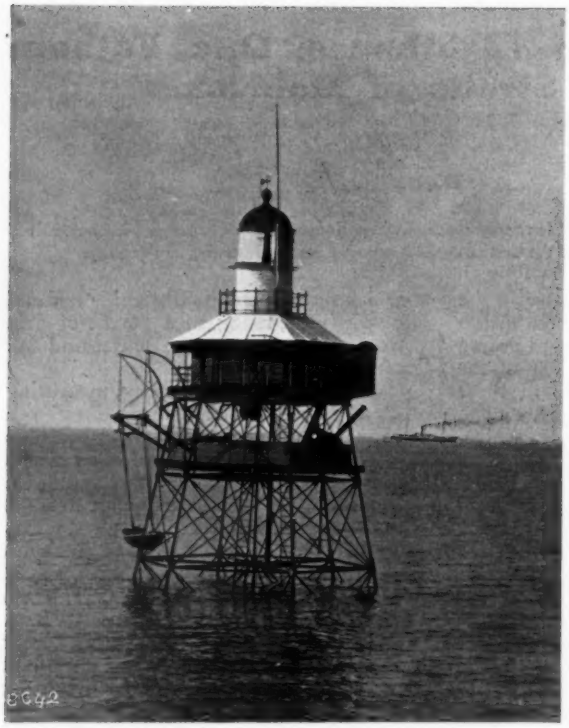
The focal plane of the new lighthouse is 92 ft. 6 in. above high water level. A white light is exhibited having a group of flashes once every 15 secs., and can be seen at a distance of 15 miles from a height of 15 ft. above the horizon. The light was exhibited for the first time on the evening of January 12, 1908.

The structure was designed by Mr. O. P. Thomas, agent in Singapore for the Colonial Ferro-Concrete Syndicate, Ltd., and being favourably reported upon by the Hon. A. Murray, M.Inst.C.E., Colonial Engineer and Surveyor General for the Straits Settlements, his tender for the work was accepted by the Legislative Council.

Owing to the very exposed position of the lighthouse, the full severity of the weather during the monsoons was felt, which made all the work below high water level anything but an easy task, the waves during the roughest weather, which happens at the beginning and end of the year, rising to a height of 8 ft. from trough to crest. The rise and fall of the tide is 14 ft.

The piles for the staging, measuring 50 ft. by 18 in. diameter, were driven from an ordinary pile driving machine which was bolted to two beams lashed transversely on two lighters, and with the use of a 2½-ton monkey, an average depth of 8 ft. was got for the piles, which were placed in three rows of five piles each, spaced 17 ft. apart with 24 ft. between the rows. After the pile heads were cut to a level of 5 ft. above h.w.o.s.t. the piles were spanned by heavy timber beams 30 ft. long by 18 in. deep and 12 in. broad, which carried the deck beams of 12 in. square timber, the decking being of 3 in. timber. On one end of the staging a hut measuring 62 ft. by 24 ft. was erected and divided into compartments for quarters for the workmen, workshop, store, office, &c., after which the pile driver, winch, boiler, &c., were hoisted on the staging, and preparations for sinking the first concrete pile commenced.

The foundation piles, seventeen in number, were constructed on an island on the west coast of the Federated Malay States, and 15 miles east from the site of the lighthouse, the concrete being gauged in the proportions of 2½ parts of granite metal broken to pass in any way through a ¾ in. cross mesh sieve, 1½ parts of sand to 1 part of Portland cement; the piles were strengthened with steel rods 1¾ in. diameter and laced with $\frac{3}{16}$ in. steel wire every six inches. The piles were moulded hollow for the sake of lightness,



SCREW PILE LIGHTHOUSE BUILT 1874, NOW REPLACED BY A FERRO-CONCRETE STRUCTURE.

50 ft. 6 in. long, eight being 18 in. square and nine 2 ft. square. They were towed singly to the site on a raft constructed of 26 hogsheads, 13 on each side of the pile, and made in four sections for convenience in releasing them therefrom. On arrival at the site, the pile was floated under the staging, and from the pile-driver, which was placed in position for driving each pile, a chain sling was made fast to the head of the pile, the lashings removed from the rafts and the pile heaved slowly up, allowing the rafts to float out under the pile by the weight of the pile. After two sections of the raft had floated away, the remaining two sections were carried under the water, and when the pile reached an almost vertical position they came swiftly to the surface, leaping about four feet out of the water.

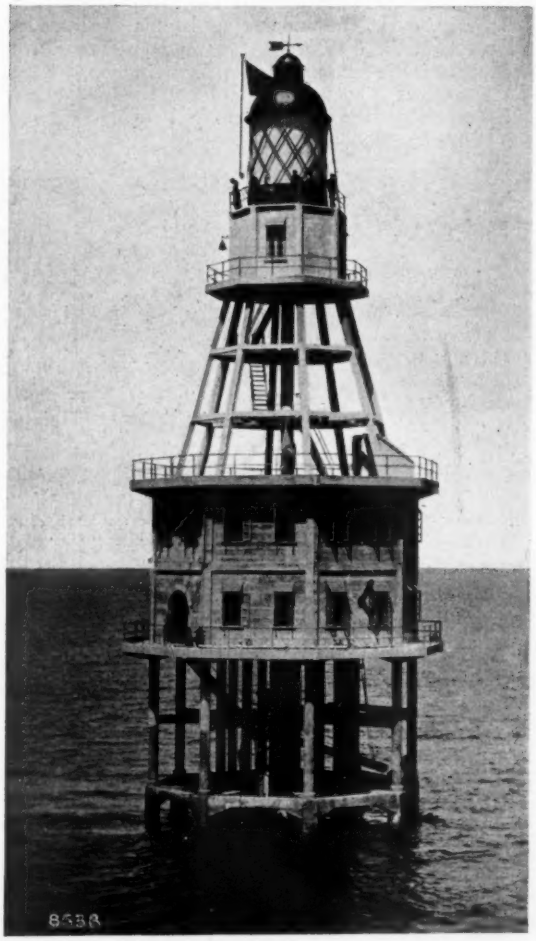
The piles were kept in their true position by two sets of guides made of timber 10 in. by 8 in., clamped to the wooden piles of the staging, the lower one about 3 ft. above low water and the upper one about 15 ft. higher, and were driven by means of two water jets actuated by a steam pump playing at the foot of the pile, and generally it was possible to sink the piles to an average depth of 15 ft. into the sand in from three to four hours. It was found that considerable erosion had taken place, due, in the writer's opinion, to the staging causing an obstruction in the course of the tides which flow very strongly, having a rate at spring tides of four knots an hour, and by the comparative easiness found in sinking the piles it was decided to lengthen one pile by 14 ft. 6 in. and try to what further depth it was possible to sink the piles.

This pile was broken down to the hollow, which was filled up with cement concrete of the same richness as the pile, and the junction made in the following manner. The lengthening bars were butted to the bars in the corners of the existing pile and the joint strapped by a sleeve 2 ft. 6 in. long. Additional bars $1\frac{3}{4}$ in. diameter and 6 ft. long, were placed in the sides of the pile, covering the joint equally, and the lacing with the $\frac{3}{16}$ in. steel wire continued as in the existing pile. Moulding boards 3 in. thick, of the necessary length, were clamped to two opposite sides of the pile and set plumb, and the open sides closed up with 1 in. boarding, 6 in. broad, as the concrete was filled in, the concrete

being carefully and well rammed until it formed a jelly-like mass. When the concrete was thoroughly set and the moulding boards removed, the piles presented a very smooth surface which required no filling in. The water jets were then fitted on the pile, the pump started and the pile sunk a further depth of 13 ft., making a total depth of 26 ft. 8½ in. into the sand, when a hard bottom was reached. It was then decided to lengthen the remaining piles by 13 ft. After the piles were broken down to the hollow which was filled with cement concrete, they were lengthened and sunk, an average depth of 26 ft. 9 in. into the sand being obtained, making an average depth below l.w.o.s.t of 52 ft. A set test was then applied to the piles, the result being from ¼ in. to ⅛ in. for the last four blows of a 2½ ton monkey falling four feet, that required by the specification being 1 in.

Although the piles were all thoroughly examined before being rafted, when the centre pile was broken down for the purpose of filling the hollow, there was evidence of considerable percolation, it being impossible to keep the water out. It was therefore decided, in consideration of this being the main pile and carrying a large proportion of the weight of the structure, to enclose it in a cylinder, 5 ft. diameter, sunk 10 ft. into the sand, excavate the sand and fill with cement concrete to the level of the main bracing. The cylinder was also sunk by the use of the water jets, six being applied inside and six outside, pressure being added by the use of two 50-ton hydraulic jacks, as the progress with the jets only was very slow.

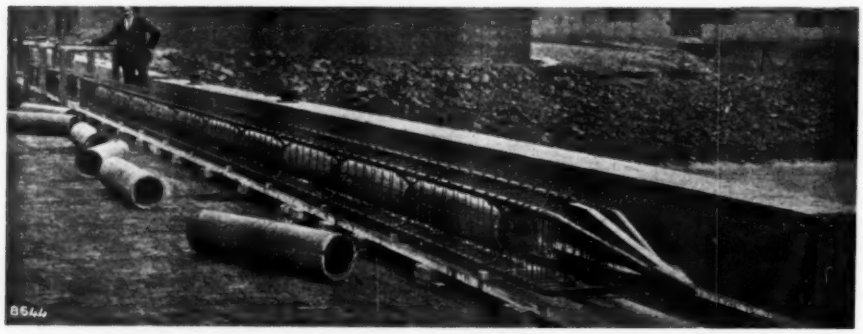
The piles were placed in an octagonal form, having a centre pile 2 ft. square, an inner ring of 18 in. square piles at a radius of 9 ft. 9 in., and an outer ring of 2 ft. square piles at a radius of 20 ft., the heads of the piles being connected by radial and ring beams at a level of 4 ft. below h.w.o.s.t. There was a slight alteration from the original design in the



ONE FATHOM BANK LIGHTHOUSE, STRAITS OF MALACCA, EXHIBITED JANUARY 12, 1908.

main bracing, as in the exposed position of the lighthouse and the more or less continued rough weather, there would have been extreme difficulty in making a thoroughly good connection to the piles, and probably great delay to the progress of the work. The bracing was moulded to the following dimensions: the radial beams 1 ft. 2 in. wide, and for half their length in the centre, in each bay, 1 ft. 2 in. deep, and at the piles 2 ft. 4 in. deep, the inner ring beams 12 in. square, and the outer ring beams 1 ft. 4 in. wide, for half their length in the centre, 1 ft. 4 in. deep and at the piles 2 ft. 8 in., the strengthening bars bolted to the web of the radial beams. In addition, the radial beams were bracketed to the piles by angle irons 3 in. by 3 in. by $\frac{3}{8}$ in. thick, as was also the outer ring beams, and round all the girders $\frac{1}{8}$ in. steel wire was wound, the spacing being 6 in. With this construction comparatively little difficulty was experienced in the moulding, and the whole of the piles being rigid, cohesion in the setting of the concrete was assured.

From each of the piles, columns 18 in. diameter, with the exception of the centre one, which was 2 ft. diameter, were carried up to the level of the first floor



18 IN. + 18 IN. HOLLOW DIAPHRAGM FERRO-CONCRETE PILES, 48 FT. LONG, SHOWING STEEL SKELETON AND FINISHED PILE.

in the original design being $1\frac{1}{4}$ in. diameter in the radial beams, 1 in. diameter in the inner ring, and $1\frac{1}{2}$ in. diameter in the outer ring beams.

In the method substituted, rolled steel joists were used, the radial beams being 10 in. by 6 in. by 45 lbs., and spanning the whole distance from the centre pile to the outer ring piles, the inner ring beams 8 in. by 4 in. by 25 lbs., and the outer ring beams 12 in. by 6 in. by 54 lbs.

The ends of the radial beams were clamped to the centre pile, and on the outer ring of piles a 3 in. solid steel bar, 5 ft. long, was cemented into the centre of the pile for a depth of 2 ft. 6 in., the outer ends of the radial beams and the ends of the outer ring beams being clamped to it, and the inner ring beams which is 21 ft. above the main bracing. In the 18 in. diameter columns eight strengthening bars 1 in. diameter were placed, lapping the pile bars by 2 ft. 6 in., and in the centre column eight bars $1\frac{1}{8}$ in. diameter, the bars being banded by $\frac{3}{16}$ in. wire every six inches. For the moulding of the columns, cast-iron moulds were made in lengths of 2 ft. 6 in., with the edges machined, and they proved very satisfactory, being easily set up, and a very smooth surface was presented on the removal of the moulds. At a distance half way between the main bracing of the first floor there was an intermediate bracing, consisting only of radial beams 12 in. wide and 14 in. deep, strengthened by four bars $1\frac{1}{4}$ in. diameter, with shearing bars $\frac{1}{2}$ in. diameter fitted

between the tension bars, and spaced 4 in. apart at the ends, increasing at the centre to 10 in.

The first floor is carried by radial beams, inner and outer ring beams with secondary radial beams from the inner ring beams to the outer edge of the gallery which is 5 ft. wide and carried by a continuation of the radial beams in the form of a cantilever from the outer ring of columns. The radial beams were moulded 10 in. wide, 12 in. deep at the centres, and at the columns 2 ft. deep, the tension bars, two in number, being $1\frac{1}{4}$ in. diameter; and in the cantilever arms for the gallery two bars 1 in. diameter and one bar $1\frac{1}{8}$ in. on the underside of the beam, the $1\frac{1}{8}$ in. bar being carried 6 ft. into the main radial beam. On the upper side of the beam there are three bars $1\frac{1}{8}$ in. diameter all carried 6 ft. into the main radial beam, the shearing bars throughout the beam being $\frac{1}{2}$ in. diameter and spaced 3 in. apart at the piles, increasing to 8 in. in the centre, except in the case of the cantilever arms where the spacing was only increased to 5 in. at the outer ends.

The secondary radial beams were moulded 10 in. deep by 8 in. wide, the tension bars (one only) being $\frac{5}{8}$ in. diameter and in the underside of the cantilever portion two bars $\frac{1}{2}$ in. diameter, in the upperside two bars 1 in. diameter, the shearing bars $\frac{1}{2}$ in. diameter and the spacing 4 in. at the beams increasing to 7 in. at the outer end of the beams. The inner ring beams were moulded $10\frac{1}{2}$ in. deep by 6 in. wide, the tension bar $\frac{5}{8}$ in. diameter, and over the columns were cantilever bars, two in the underside $\frac{1}{2}$ in. diameter and two in the upperside $\frac{5}{8}$ in. diameter, the shearing bars being $\frac{1}{2}$ in. diameter spaced from 2 to 9 in. The outer ring beams were moulded 10 in. wide, 12 in. deep at the centre and 2 ft. deep at the columns, the tension bars, two in number, being 1 in. diameter and over the cantilever bars, one in the underside 1 in. diameter, and in the upperside three bars 1 in. diameter, the shearing bars being also $\frac{1}{2}$ in. diameter and spaced from 2 in. at the ends to 7 in. at the centre. Around the outer edge of the gallery there is a beam moulded 10 in. deep and 8 in. wide, strengthened

CONCRETE PILE FLOATED UNDER STAGING.

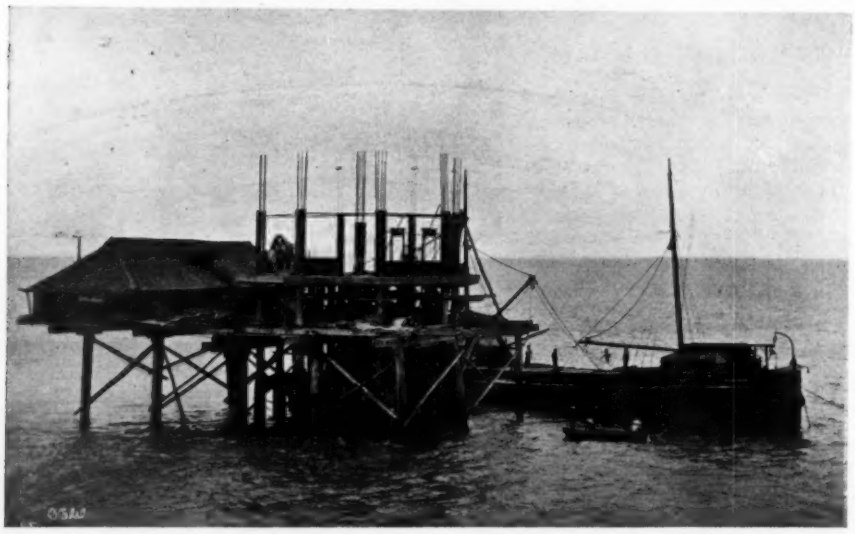
by two tension bars $\frac{1}{2}$ in. diameter with one cantilever bar $\frac{5}{8}$ in. diameter in the underside and one $\frac{1}{2}$ in. diameter in the upperside over the ends of the secondary radial beams, and the continuations of the main radial beams and the shearing bars of $\frac{1}{2}$ in. diameter were spaced 9 in.

The floor was 5 in. thick finished with a rendering of cement mortar gauged in the proportions of 2 of sand to 1 of cement, and strengthened by $\frac{5}{16}$ in.

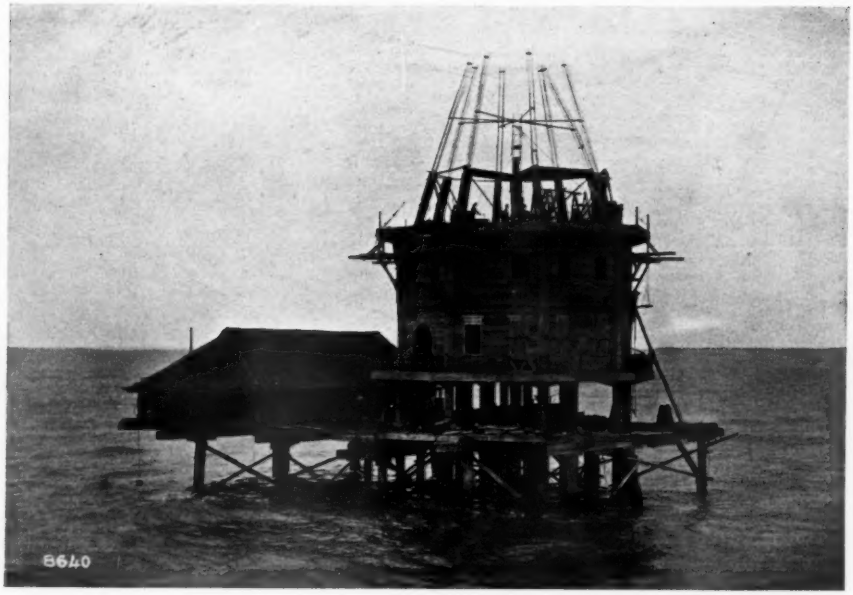
diameter bars spanning the floor between the main radial beams and spaced 12 in., and by cantilever bars over the beams spaced 8 in., the gallery being also strengthened by $\frac{5}{16}$ in. bars spanning the space between the outer gallery beam and outer ring beam carried 3 ft. into the floor on the inside and spaced 6 in.: cantilever bars were also put in over the beams, the spacing being 6 in.

The gallery is reached from boat by a teak ladder in two flights, the lower flight being hinged to a platform, in ferro-concrete, built on one of the 18 in. diameter columns at a level of 4 ft. above h.w.o.s.t., and reaching to l.w.o.s.t. and the upper flight fastened to the platform at the lower end, and at the upper end, to the continuation of the main radial beam and a well protected by a wrought iron grating was formed in the gallery. The concrete for the remainder of the structure was gauged in the proportions of 3 parts granite metal, 2 parts of sand and 1 part of Portland cement.

From the first floor to the third floor, a height of 24 ft., on the line of the outer ring beams the space was walled in by walls 4 in. thick, strengthened by $\frac{5}{16}$ in. diameter bars laid vertically and horizontally 6 in. apart, and the centre column carried up for the same height and moulded to the same section as that below the level of the first floor. At the corners over the outer ring columns are five sided pillars projecting $4\frac{1}{2}$ in. beyond the outside of the wall to the height of the third floor, strengthened by four vertical bars $1\frac{1}{4}$ in. diameter and laced every six inches by $\frac{3}{16}$ in. diameter wire. Midway between the corner pillars are pillars 12 in. by 10 in. flush with the wall on the outside, the four strengthening bars being $\frac{1}{2}$ in. diameter and laced every six inches with $\frac{1}{8}$ in. diameter wire. On the first floor are two store rooms, the internal walls radiating at a distance of 6 ft. from the centre of the building, for oil, lamp stores, &c., two water tanks in ferro-concrete, each of a capacity of 1,000 gallons, the water being collected on the third floor which is graded to a gully at the head of a down pipe leading to the



ONE FATHOM BANK LIGHTHOUSE, STRAITS OF MALACCA. THE WORK OF CONSTRUCTION, MAY 2, 1907.



ONE FATHOM BANK LIGHTHOUSE, STRAITS OF MALACCA. PROGRESS TO AUGUST 24, 1907.

tanks below, special provision being made so that the water for the first few minutes can be run to waste before entering the tanks, thus ensuring as far as possible clean water for drinking and culinary purposes.

Ample room is also provided for kitchen and dining hall on two sides of the building and there is also a bath-room and closet. Entrance to the floors is from the gallery through an arched opening in one side of the wall 6 ft. wide and 8 ft. high, and light and ventilation is given from two windows on each side of the building, measuring 6 ft. 6 in. by 3 ft., and opening in two halves.

The second floor is reached by a teak staircase which continuing to the third floor is protected by a hood in ferro-concrete, formed round and over the well; the floor is moulded to a thickness of $4\frac{1}{2}$ in., and the size and spacing of the bars, also the arrangement and dimensions of the beams, are the same as that of the first floor, and for embellishment a string course 12 ft. deep and projecting $4\frac{1}{2}$ in. was formed at this level. On this floor are the sleeping quarters for the keeper and his crew; office and visitors' room are also provided.

The third floor overhangs the building by 4 ft., thus giving a width of 44 ft. on the flat, and by the formation of a kerb round the outer edge there is ample catchment area for water supply. This floor is moulded to an average thickness of $4\frac{1}{2}$ in., the size and spacing of the bars and also the arrangement and dimensions of the beams being the same as that of the first floor. At a radius of 24 ft. from the centre, eight raking columns, 12 in. by 12 in., and strengthened by four 1 in. diameter vertical bars bound by $\frac{3}{16}$ in. diameter wire every 6 in., spring up to the level of the service floor, a height of 30 ft., the radius at the heads of these columns being 9 ft. 3 in.

The central column, 2 ft. diameter, which is carried to the top of the building, is moulded hollow above the third

ONE FATHOM BANK LIGHTHOUSE, STRAITS OF MALACCA. PROGRESS PHOTO, DECEMBER 2, 1907.

floor to form a weight tube, the inside diameter being 12 in.; the strengthening bars, 12 in number, are 1 in. diameter and are banded every 6 in. with $\frac{3}{16}$ in. wire, and at a height of 4 ft. 6 in., an opening 18 in. by $10\frac{1}{2}$ in. wide is formed in the tube for convenience in placing the weights on the weight rod.

Between the third and service floors there are two sets of bracings binding and strengthening the raking columns to each other and to the central column. The lower bracing is moulded 10 in. deep and 9 in. wide, two bars $\frac{5}{8}$ in. diameter on top and two bars $\frac{3}{4}$ in. diameter in underside, the four being bound every 12 in. by $\frac{3}{16}$ in. diameter wire; the upper bracing is moulded 9 in. by 8 in. wide, the arrangement and size of bars being the same as in the lower bracing. The service floor is reached by three flights of ladders, a platform being made at each of the bracings, and round the well in the service room a rail is fixed with a gate at the head of the ladder. This floor is moulded 4 in. thick and carried by eight radial beams 9 in. deep by 6 in. wide, which overhang the raking columns 4 ft. to carry a gallery. The heads of the raking columns and the outer ends of the radial beams are bound by beams of the same dimensions as the radial beams and strengthened by one tension bar $\frac{1}{2}$ in. in diameter, with $\frac{3}{8}$ in. diameter shearing bars spaced 10 in. at the centres to 4 ft. at the ends. Two $\frac{5}{8}$ in. diameter cantilever bars are also inserted in the continuation of the radial beams, and the floor is strengthened in a similar manner to the other floors.

Corner pillars, 12 in. by 9 in., strengthened by four vertical bars $\frac{3}{4}$ in. diameter and laced every 6 in. by $\frac{3}{16}$ in. diameter wire, were carried up from the heads of the raking columns for a height of 11 ft. $3\frac{1}{2}$ in., and a wall 4 in. thick strengthened in a similar manner to the lower walls moulded between them. The floor at this top level was moulded 4 in. thick and carried by eight radial beams 9 in. by 6 in. each, strengthened by two tension bars $\frac{3}{4}$ in. diameter with shearing bars $\frac{3}{8}$ in. diameter, spaced 10 in. to 4 in. apart, and the cast iron base of the lantern, the diameter of which was 12 ft., was bolted to this floor by twenty-four holding down bolts $1\frac{3}{4}$ in. diameter.

The moulding boards for all the beams and the columns above the first floor were of $1\frac{1}{2}$ in. and 2 in. thickness, according to their length, and that for the walling were of 1 in. grooved and tongued boarding 6 in. wide. Generally the surface presented after the removal of the moulding boards was very smooth, the only exception being a slight warping in the 1 in. boarding owing to the alternate changes of wet and dry under the tropical sun. During the setting of the concrete the work was occasionally

sprinkled with water to prevent it drying too quickly.

The time employed in the construction of the lighthouse from the time the piles were sunk was 12½ months, and for the erection and fitting up of the lantern and apparatus, which together weighed 17½ tons, six weeks.

The total weight of the structure is approximately 997 tons.

The temporary wooden staging was erected by Mr. Thomas, who also constructed the ferro-concrete piles for the foundation of the lighthouse, when, owing to his departure for Australia, the contract was transferred to Messrs. Riley, Hargreaves & Co., Limited, Engineers and Shipbuilders, Singapore, who completed the contract in a very satisfactory manner, and are now the agents for the Colonial Ferro-Concrete Syndicate, Limite d.

The writer was Resident Engineer on the work and supervised the construction on behalf of the Government.

M. Eiffel's Experiments on the Resistance of Air.

The precise estimation of the pressure of air on surfaces has long been recognised as one of the most important questions in bridge and structural engineering. The very high speeds now reached by self-propelled vehicles and locomotives, which are likely to still further increase with the development of mechanical and electrical design, involves also the correct estimation of the forces set up and the power consequently absorbed when surfaces are propelled against wind pressure. Further, the future of the aeroplane depends upon an exact knowledge of the resistance of the air set up by the motion of planes. The knowledge available on the subject is small, and quite inadequate to the requirements of modern engineering, especially with regard to high speeds. M. Eiffel's investigations on the subject, of which the following is a brief account, are well-timed, and the results obtained by him are of the utmost importance.

THE object of the investigation, of which the following is a brief account, was to obtain some precise information with regard to the resistance of air on plates of various forms, which were allowed to fall vertically at speeds of from 60 ft. to 130 ft. per second.

These experiments possess an increased importance by reason of the difficulty of obtaining speeds up to 130 ft. per second under suitable conditions; in fact, such have not hitherto been obtained, existing data having been derived from speeds not exceeding 36 ft. per second. Velocities higher than this, however, must be taken into account in the design of all structures of high velocity vehicles, and in connection with the propulsion and lift of aeroplanes.

Even in the case of low velocities, and in spite of the numerous experiments that have been carried out therewith, the results so far obtained show no very satisfactory agreement, and it will suffice to recall that the values given for the co-efficient of air resistance vary between 0·07 and 0·13. Such a variation can only be explained by the diversity of the methods employed, and by the difficulties involved in certain of them, particularly those utilising the rotational movement of vanes. While it is of importance to engineers that a formula for low velocities should be definitely ascertained, it is equally, or even more necessary in the case of higher velocities. So far, however, experiments have been made only under conditions far from exact, with railway cars, or with vanes

in which the violent eddies set up have falsified the results. It occurred, therefore, to M. Eiffel that the celebrated tower designed by him would afford the necessary facilities for obtaining rectilinear movements in the shape of a vertical fall, and, moreover, at speeds of over 130 ft. per second; and in collaboration with M. Rith, he has carried out an exhaustive series of experiments, affording much valuable information.

EIFFEL'S METHOD AND APPARATUS.

The principle adopted was as follows. From the second stage of the tower, that is at a height of 380·48 ft., an apparatus weighing 264 lbs. was to be allowed to fall. This comprised the surface or plate, the air-resistance of which was to be ascertained, and a cylindro-conical case containing the necessary measuring instruments. The problem involved was how to bring this apparatus to rest at ground level without shock or injury. To this end a very smooth cable was suspended from the second stage (*Ca*, Figs. 1 and 2), and kept in a vertical direction therefrom by means of a heavy suspended weight. Down this cable the apparatus (Fig. 2) was allowed to slide freely. For a distance of about twenty-five yards from the ground level the diameter of the cable was enlarged progressively from ·7 to 1·6 in., thus determining the opening of a pair of jaws to which were attached the powerful

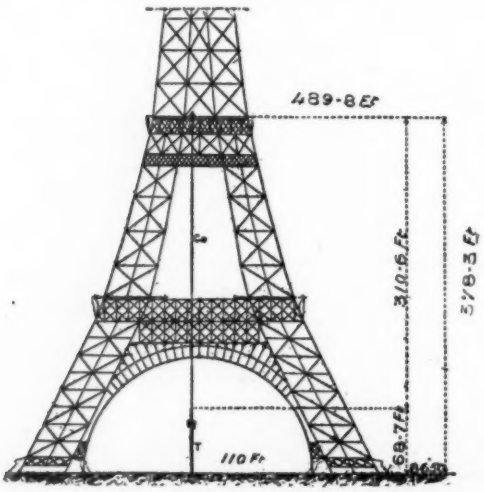


FIG. 1.

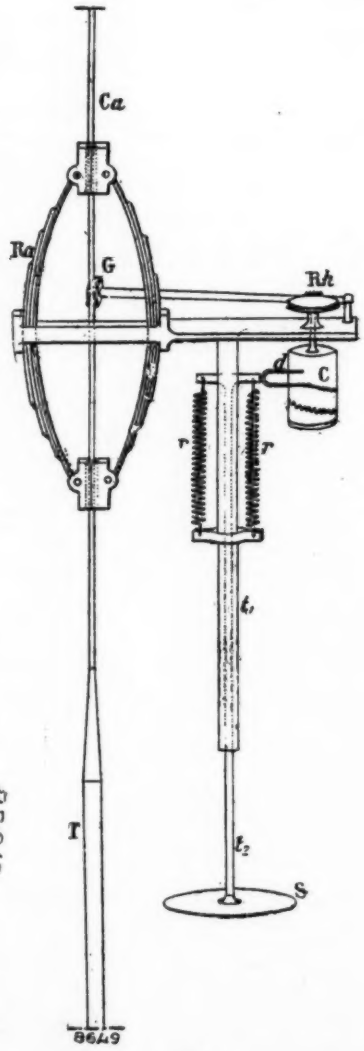


FIG. 2.

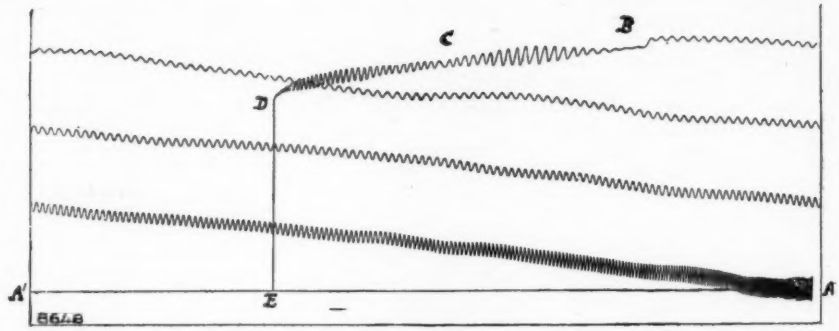


FIG. 3.

A Starting point. B Braking effect commences. D and E Position of rest.

springs R, carrying the apparatus. A braking effect, under a loading of the springs of 8,800 lbs., was thus produced, which deadened the shock of descent, and brought the apparatus safely to a standstill.

The apparatus, which is in duplicate, consists of the plate S, to be experimented with, carried by a rod t_2, sliding within a hollow tube t_1. The lower part of the latter is filled with oil, thus providing for the lubrication, and acting as a buffer to deaden the sudden motion of t_2 at the end of the descent. The upper portion of the tube t_1 is slotted to permit the projecting arms of t_2 to slide freely. To these arms are fixed a pair of carefully calibrated springs r r, the lower ends of which are attached to a fixed yoke. The action of these springs being antagonistic to that of the resistance set up by the air against the plate S, this resistance can be deduced from the elongation of the spring, that is to say, by the displacement of the plate in relation to the rest of the apparatus. This displacement is indicated by a bristle carried on one of the prongs of a tuning fork d, the bristle bearing lightly on a vertical smoked drum C, and thus registering the vibrations. The drum is movable about its axis, its rotation being effected through a worm and worm wheel R, by means of a roller G, cut with very fine teeth, and pressed against the cable by a spring. The rotation of the drum is thus proportional to the length of fall, and the line traced by the bristle indicates for each value of the vertical distance traversed, the tension of the dynamometric springs, which is the measure of the pressure on the plate S.

It is not, however, the air resistance per distance of fall that is required, but the proportion of air resistance to velocity which is obtained by measuring the time occupied for each fall. This is given by the total number of vibrations made by the tuning fork, the latter making 100 vibrations per second from the start. The curve traced on the drum (Fig. 3) by the fork is thus a helix, and shows the space fallen through, time of fall, and the tension of the springs. The velocity is deduced from the first two quantities, and the resistance of the air from the third.

In reality the tension of the springs does not directly measure the pressure of air on the plate, but this is obtained by means of a relation that the line drawn on the drum entirely determines. The product of the mass $\frac{p}{g}$ of the plate and its support, by its acceleration $\frac{d^2H}{dt^2}$ is equal to the forces which act on it, that is to say, to the weight p augmented by the tension of the springs and diminished by the resistance R of the air. We have thus

$$\frac{p}{g}\frac{d^2H}{dt^2} = p + f - R$$

whence

$$R = f + \frac{p}{g}\left(g - \frac{d^2H}{dt^2}\right)$$

where H is the distance fallen through by the sliding part.

This relation gives R, since the diagram permits the determination of H and f as functions of t. M. Eiffel has devised, however, a simple graphical method simplifying the operations involved and showing the degree of approximation obtained. The details are given at length in M. Eiffel's publication, and need not be given here.

The principal numerical data relative to the apparatus are as follows. The height of free fall was 95·60 m. (313·5 ft.); the surface of the drum turned 10 mm. per metre of fall, or about $\frac{1}{100}$th of the height. As the tuning fork made 100 vibrations per second, the velocity in metres was virtually represented by the number of tens of millimetres which measured the horizontal projection of the undulations traced on the drum. Five pairs of springs were employed, of different flexibilities. The apparatus was suspended at the point of departure by a cord, which was only severed when the wind had completely dropped. Under favourable conditions five experiments were made per day, involving the services of ten persons.

RESULTS.

To compare the results obtained they have been reduced to a temperature of 15° C. and an atmospheric pressure of 760 mm. The results given in the table below were obtained with two circular plates, the surfaces of which measured $\frac{1}{16}$ sq. m. and $\frac{1}{2}$ sq. m. respectively.

From these figures the following important approximation is arrived at:—

For the small plate, $R = 0{\cdot}064\ SV^2$
For the large plate, $R = 0{\cdot}078\ SV^2$

All the experiments gave analogous results, showing that the Newtonian formula can be adopted:—

$$R = KSV^2$$

where K = constant for a determined surface, that is, the co-efficient of resistance or the specific resistance of the plate.

M. Eiffel found within the limits imposed, of 18 m. and 40 m. (59 ft. and 131·2 ft.), the index of velocity steadily increases, passing the value 2 for a speed of 33 m. (108 ft.), but remains in the neighbourhood of 2 sufficiently to establish the proportionality of the resistance to the square of the velocity. He has not found, however, for the co-efficients of resistance the high values extending to 0·13, that certain investigators have proposed and which are still used by some engineers, but the results of experiments repeated under varying conditions and giving numbers sensibly in agreement, show that the specific resistance is between 0·07 and 0·08. The latter value appears to be a maximum reached only in the case of plates of large dimensions. The average of

Distance of fall.	Experiment No. 1. Circle (0·67 sq. ft.) $\frac{1}{16}$ sq. m.; 0·282 m. diam.			Experiment No. 32. Circle (5·35 sq. ft.) $\frac{1}{2}$ sq. m.; 0·798 m. diam.		
	Resistance of air, R.	Velocity, V.	$\frac{R}{SV^2}$	Resistance of air, R.	Velocity, V.	$\frac{R}{SV^2}$
m.	kg.	m.		kg.	m.	
20	1·41	19·04	0·063	13·8	18·88	0·078
40	2·86	26·44	0·065	25·4	25·40	0·079
60	4·08	32·06	0·064	35·5	30·10	0·079
80	5·17	36·51	0·062	42·9	33·30	0·077
95	6·12	39·22	0·064	48·6	35·29	0·078
Average			0·064	Average		0·078

200 co-efficients that were obtained for all the plates experimented upon and for all velocities was 0·074.

The following table gives, in a condensed form, the mean results obtained :

	Area.				
	0·67 sq. ft. $\frac{1}{15}$ sq. m.	1·34 sq. ft. $\frac{1}{8}$ sq. m.	2·68 sq. ft. $\frac{1}{4}$ sq. m.	5·35 sq. ft. $\frac{1}{2}$ sq. m.	10·7 sq. ft. 1 sq. m.
Circle	0·068	0·071	0·074	0·077	—
Square	0·070	0·072	0·075	0·077	0·079
Rectangle	—	0·073	0·075	—	—
Oblong	0·073	0·074	—	—	—

This table shows the slow augmentation of the co-efficient with the surface of the plate and its perimeter. The latter point is strikingly confirmed by an experiment with a lattice-work plate K being found = 0·88 instead of 0·075 for a plate not so latticed. Plates placed side by side appear to have but little influence on each other, but when spaced one above the other their total resistance appears to considerably decrease. Plates so connected as to form a vertical cylinder gave analogous results. Air resistance is greatly reduced if the front surface terminates in a point (co-efficient of a cone, 60 deg. = 0·015) ; it is sensibly increased if the front surface is concave (co-efficients of hemispherical concave sections = 0·072 or 0·084 according to the diameter). The results in the case of dihedra are represented by a curve of great regularity. Inclined planes gave a greater resistance than dihedra. This resistance P, necessarily normal to the plane, increases at first proportionally to the angle i which forms a perpendicular to the plane with the direction of movement ; commencing at 30 deg. up to 90 deg. it can be taken, without sensible error, as equal to the resistance P_{90} offered by a plane normal to the wind, which leads to a very simple practical formula $\frac{P_i}{P_{90}^{\circ}} = \frac{i^{\circ}}{3^{\circ}}$ for inclinations above 30 deg. and beyond $P_i = P_{90}$. These experiments, made with surfaces 0·50 m. sq., placed symmetrically to counterbalance the horizontal components presented certain difficulties, but their agreement appeared to be a guarantee of their exactitude.

The differences between the co-efficients given by the same plate appear to have some importance when compared with the results of other physical measurements ; on the contrary, they appear small when compared with the values obtained by other experimenters.

For surfaces normal to the wind the co-efficient 0·12 that has hitherto been generally accepted, must be abandoned in favour of the general rule 0·08. As regards oblique surfaces, as M. Eiffel's researches were limited to a 0·50 m. rectangular plate, further investigation is necessary before definite results can be obtained. This M. Eiffel proposes to take up with a different form of apparatus, by which he also hopes to obtain some results with regard to the point of application, concerning which the greatest uncertainty prevails.

Live Steam Feed Heating.

The following communication has been received from Mr. A. H. Gibson, A.M.Inst.C.E., in reply to Mr. S. Bilbrough's article that appeared in our last number, wherein the hitherto accepted theory that the rate of transmission of heat through a boiler plate is greater when the water is boiling than when being heated, was challenged.

As Mr. Bilbrough, in his interesting article on the "Transmission of Heat through a Boiler Plate," in your May number, has done me the honour of noticing some of the opinions expressed by myself in an article in your magazine in January, perhaps you would be so good as to extend to me the courtesy of your columns, so that I may explain why the results published by Mr. Bilbrough have not yet upset my faith in the efficacy of live steam feed heating.

To begin with, let us consider the evidence for and against. As regards the latter, we have the results of a single experiment by Mr. McLachlan, and of two experiments on a small scale by Mr. Bilbrough. Of these more later. As regards the former, we have the evidence, not deduced from laboratory experiment, of a large—a very large—number of men who are not at all interested in the scientific side of the question, but to whom the coal bill at the month end marks at once the economical success or failure of any alteration to the steam raising plant, and who are practically unanimous in testifying to the increase in economy following the installation of the live steam heater. I notice that Mr. Bilbrough deprecates this testimony on the ground that, following any such installation, the boiler-house would receive extra "benevolent" attention from its owner. As far as the writer's experience goes, however, it is only after considerable persuasion on the agent's part that consent is given to the installation of such an apparatus, and the owner, being merely human, is hardly likely to pay a bonus to his stokers for extra care in stoking, when, to justify his scepticism, the opposite course would be more natural. Moreover, the fact that in many lines of steamships this system is applied to each new boat as it is equipped, and that it appears to be spreading rapidly in its application to locomotive work, speaks for its practical value in a manner which will require a good many results, deduced from small experimental boilers, to counteract.

In passing, I would mention that the conclusions drawn from his two experiments by Mr. Bilbrough, as regards the influence of the velocity of flow of hot gases and of water over the heating surfaces, are directly opposed to those drawn from experiments on a much greater scale by Professor Osborne Reynolds, Dr. Nicholson and Dr. Stanton, as well as by a U.S. Commission. Further, on the direct question as to the relative efficiency of a heating surface when heating and when evaporating water, we have the evidence of a large number of experiments by Bramwell and Anderson, as well as the most suggestive experiments by Miss Bryant quoted in my own article.

Granted that in the first two series quoted the source of heat was live steam, and that it is perhaps not legitimate to extend the results in their entirety to the case in which the difference of temperature is much greater than in these experiments, yet there would appear to be no reason why the effect, though of different relative magnitude in the latter case, should not be of the same kind as in the former. Moreover, in Miss Bryant's experiments, as in those of Mr. Bilbrough, the source of heat was a naked flame.

Unfortunately I have not had time to more than glance at Mr. McLachlan's

paper, but I notice from the printed report of the discussion that much criticism was applied to the experiment in general by those present, and that the author's deductions were strongly combated by the majority of the speakers.

But Mr. Bilbrough's experiments are more to the present point, and I would submit that these are practically useless for settling the vexed question without further very substantial confirmation, for the following reasons:—

(1.) If the theory accepted by myself and others is correct, the rate of transference of heat from some point in a heating surface to the water is much greater at the instant of steam formation than when the water is being heated. Once a steam bubble is formed at a point, the transmission of heat will practically cease until this bubble is removed and fresh water is brought into contact. If this theory be accepted (and it is freely acknowledged that in our present state of ignorance of the mechanisms of ebullition it is solely theory), then such an apparatus as Mr. Bilbrough's, where a vigorous circulation is almost impossible, is not at all analogous to the state of affairs actually obtaining in a steam boiler.

(2.) In the heat balance, the dryness of the steam has been taken as ·98. In Regnault's experiments, however, from which the heat values used by Mr. Bilbrough are taken, steam formed in the same way as this, was taken as being dry. This in itself would cause a balance of practically 2 per cent. in favour of the theory.

(3.) Radiation laws have been neglected by Mr. Bilbrough. Now, assuming that the air temperature throughout was 70° F., the mean difference of temperature between the water and air during the period of water heating is approximately 67° F., while during the period of evaporation it is 134° approx. On the assumption that radiation may take place over the whole of the top surface and say half the sides, this gives a radiating surface of 1·37 ft. Using Dulong and Petit's values for the radiation per square foot per unit difference of temperature we get a radiation of 1·47 B.T.U. per minute during the first period and 2·97 during the second, giving an excess radiation loss during the second period of 1·7 B.T.U. per minute. This amounts to practically 3½ per cent. of the heat entering the steam, and, in combination with the 2 per cent. previously accounted for, shows an increase in efficiency of 5 per cent. during the period of evaporation.

Further, if the sketch of the apparatus is correct, part of the spray caused by condensation of the escaping steam, falling on to the top of the boiler, necessitating its re-evaporation, may lead to an error of proportionately large magnitude.

(4.) While the construction of the burner is not perfectly clear, it is evident that if the pressure in the oil chamber were maintained constant, any variation in the temperature in this chamber would lead to a variation in the weight of oil flowing per minute.

From the description, one is not able to ascertain whether this temperature was measured, whether the weight of oil used per unit time at different periods of the experiment was measured, or whether sufficient precautions were taken to ensure the absence of any draughts which in such an exposed apparatus might entirely invalidate the reliability of the results. In the experiments of Bramwell and Anderson the method of heating did enable these sources of error to be entirely eliminated.

In conclusion, I hope I have made it clear that Mr. Bilbrough's experiments do not weaken the case for the live steam feed heater, but rather tend to strengthen it.

While saying this, I freely acknowledge that the heater is not a magical device, which, applied in season and out, will invariably cause economy. Where a boiler is easily worked, so that the process of heat conduction from plate to water is sufficiently rapid to enable the boiler to fulfil its functions, the addition of the heater is not likely to lead to any appreciable economy. Where the boiler is most heavily worked, its advantage is likely to be most felt.

I am, yours faithfully,

A. H. GIBSON.

Manchester,
May 8th, 1908.

Testing a Centrifugal Fan.

IV.

By C. L. BROWNE.

This is the fourth and concluding portion of this series. The whole of this article should follow the matter as concluded in the December issue.

In order to better appreciate the special features of this fan, it might be as well to compare it with fan No. 1, which, it may be stated, is by no means in the first rank with more expensively designed fans, the price of which puts them out of the running as commercial machines in this country.

Suppose that it is required to instal a fan to deal with the products of combustion of a battery of boilers, and to pass 200,000 cub. ft. of gases per minute at 500° F., and that a static water gauge of 2½ in. must be maintained in the main flue near the fan. Suppose, also, that the chimney into which the fan discharges is of such a size and height that the pressure at the fan discharge will be that of the atmosphere.

Looking down the test sheet of fan No. 1, it will be necessary in the first place to select the mechanical efficiency at which the fan shall work. Unfortunately the highest mechanical efficiency coincides with a very low volumetric efficiency, so, in order that the fan may not be unduly large and costly, a mechanical efficiency of ·472 in the table will be decided upon. It may also be noted that the fan tested, and on which the values η_m were based, was by no means a large one, and as with larger fans the friction between the air and the fan sides per cubic foot of air discharged is less than with smaller fans, the larger fan is likely to be the more efficient of the two.

Now, upon reference to the table of velocities,* it will be seen that the velocity corresponding to 2½ in. of water gauge at 500° F. is 8,560, and from column 4 in the test sheet it appears that the velocity of discharge from the fan is ·391 times this value, or 3,350 ft. per minute, and the discharge area of the fan will be $\frac{200,000}{3,350}$ sq. ft., say 60 sq. ft., and as the discharge outlet is square, its width will be say 7·75 ft.

From the proportionate figures given in the right-hand top corner of the test sheet, the diameter of the blast wheel will be $\frac{7·75}{·56}$ say 13·85 ft.

From the first column of the test sheet it will be seen that the tip speed required to give the volume and mechanical efficiency desired is (8,560 × 1·119) = 9,570 ft. per minute, hence the revolutions per minute required will be $\frac{9,570}{13·85 \times \pi}$ = say 220.

Now turn to test sheet No. 2, and take the mechanical efficiency as being ·47, practically the same as in the previous case.

Referring to the test sheet, the discharge velocity will be 8,560 × ·483 = say 4,140 ft. per minute, and the discharge area $\frac{200,000}{4,140}$ = 48·4 sq. ft., and its width 6·95 ft.

Referring to the sketch, the diameter of the wheel $\frac{6·95}{·8}$ = 8·68 ft., and the tip speed required 8,560 × ·834, say 7,150 ft. per minute, and its revolutions per minute $\frac{7,150}{6·95 \times \pi}$, say 330.

The size of No. 2 fan to perform the same duty is substantially smaller than No. 1 fan, but the revolutions required per minute are very much higher, being in the proportion of 330 to 220. Thus it is obvious that a very much smaller, and consequently less costly, motor or engine will be required to drive No. 2 type of fan direct.

An interesting point with reference to No. 2 fan is that, although its manometric efficiency is much higher than that of No. 2 fan—the tip speeds in this case being $\frac{·834}{\sqrt{2gH}}$ and $\frac{1·119}{\sqrt{2gH}}$ respectively—the very much higher volumetric efficiency of the former allows a smaller wheel to be used, and consequently the required number of

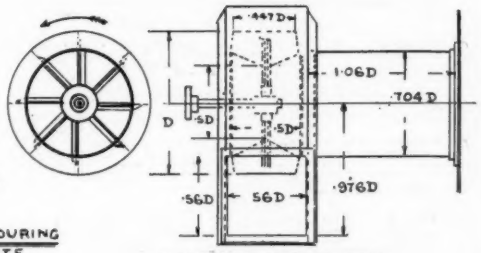
* Vol. XVII., pp. 218, 219.

TEST SHEET No 1

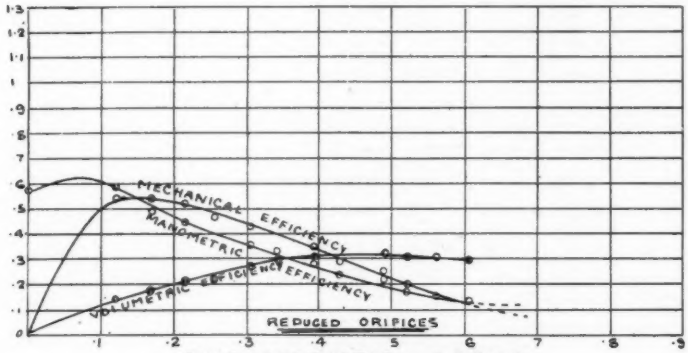
• ASSUMED COEFFICIENT OF INFLUX $\gamma = .83$. ALL OTHER COEFFIENTS OF INFLUX AND EFFLUX ARE ASSUMED TO BE UNITY.

o MECHANICAL EFFICIENCIES η — INCLUDE FRICTION OF ONE FAN SHAFT BEARING.

NOTE: TIP SPEED OF WHEEL DURING TEST 8000 FEET PER MINUTE



AMERICAN VENTILATOR



CHARACTERISTIC CURVES

$\frac{C_v}{\sqrt{2gH}}$	• $\frac{u_2}{\sqrt{2gH}}$	$\frac{u}{\sqrt{2gH}}$	$\frac{V_4}{\sqrt{2gH}}$	o η —	$\frac{gH}{C^2}$	$\frac{Q}{C_v DW}$	$\frac{Q}{DW\sqrt{2gH}}$
·929	0	0	0	0	·575	0	0
·972	·185	·0472	·197	·538	·582	·1328	·129
1·014	·245	·0628	·261	·536	·488	·1700	·172
1·065	·306	·0784	·326	·515	·440	·2028	·216
1·119	·3675	·0940	391	·472	·400	·2175	·259
1·180	·429	·1097	·456	·430	·354	·257	·303
1·236	·481	·1250	·522	·407	·327	·2805	·346
1·324	·550	·1401	·585	·345	·279	·297	·393
1·436	·612	·1558	·650	·289	·234	·300	·431
1·536	·698	·1778	·742	·253	·215	·317	·487
1·703	·748	·1874	·784	·195	·173	·305	·520
1·849	·800	·2040	·850	·154	·147	·304	·560
2·030	·860	·2190	·914	·121	·122	·298	·605

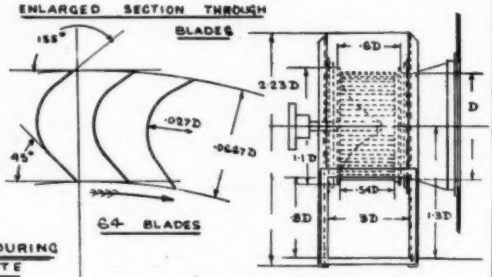
8276

TEST SHEET Nº 2

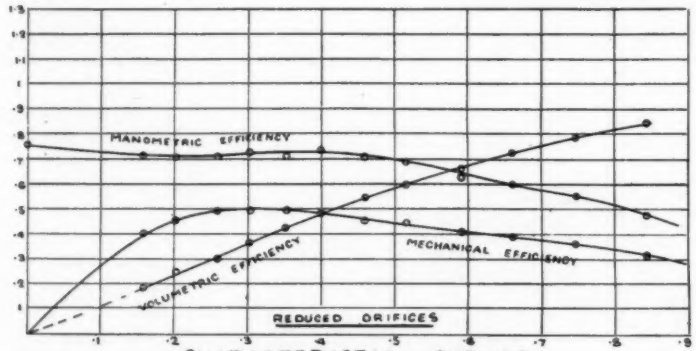
- ASSUMED COEFFICIENT OF INFLUX = Y = ·83. ALL OTHER COEFFIENTS OF INFLUX AND EFFLUX ARE ASSUMED TO BE UNITY.
- MECHANICAL EFFICIENCIES η_m INCLUDE FRICTION OF ONE FAN SHAFT BEARING

NOTE: TIP SPEED OF WHEEL DURING TEST = 6000 FEET PER MINUTE

ENLARGED SECTION THROUGH BLADES



SER TYPE BRITISH EXHAUSTER



CHARACTERISTIC CURVES

$\frac{C_1}{\sqrt{2gH}}$	$\frac{u_2}{\sqrt{2gH}}$	$\frac{u_1}{\sqrt{2gH}}$	$\frac{V_3}{\sqrt{2gH}}$	η_m	$\frac{gH}{C_1^2}$	$\frac{Q}{C_1DW}$	$\frac{Q}{DW\sqrt{2gH}}$
·816	0	0	0	0	·752	0	0
·837	·1843	·0717	·1748	·398	·717	·180	·151
·840	246	·0950	·2415	·457	·705	·239	·202
·844	·3130	·1214	·3073	·483	·704	·299	·260
·838	·3659	·1427	·3590	·480	·721	·360	·302
·837	·4310	·1670	·4235	·490	·717	·420	·352
·834	·492	·1910	·4830	·470	·725	·480	·400
·862	·530	·2050	·5205	·451	·703	·539	·461
·880	·616	·2380	·6050	·445	·684	·599	·515
·897	·678	·2620	·6650	·402	·621	·660	·592
·916	·740	·286	·7260	·381	·592	·720	·660
·960	·795	·3075	·7800	·351	·547	·778	·748
1·011	·864	·3340	·8480	·310	·476	·835	·845

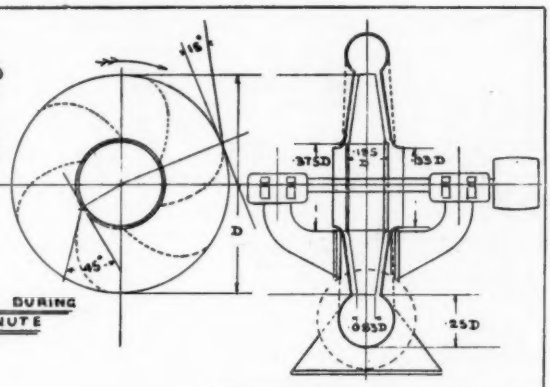
8277

TEST SHEET No 3

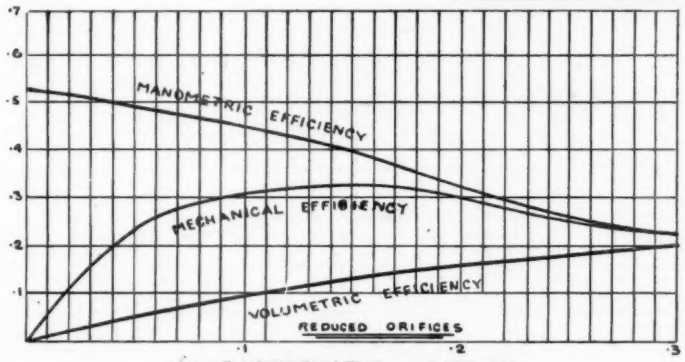
o ASSUMED COEFFICIENT OF INFLUX $\gamma = .5$. ALL OTHER COEFFIENTS OF INFLUX AND EFFLUX ARE ASSUMED TO BE UNITY.

MECHANICAL EFFICIENCIES η— INCLUDE FRICTION OF FAN SHAFT BEARING.

NOTE: TIP SPEED OF WHEEL DURING TEST = 6500 FEET PER MINUTE



CONTINENTAL CUPOLA BLOWER



CHARACTERISTIC CURVES

$\frac{c_1}{\sqrt{2gH}}$	$\frac{u_2}{\sqrt{2gH}}$	$\frac{u_1}{\sqrt{2gH}}$	$\frac{v_2}{\sqrt{2gH}}$	η—	$\frac{gH}{c^2}$	$\frac{Q}{qDW}$	$\frac{Q}{DW\sqrt{2gH}}$
·977	0	0	0	0	·523	0	0
·986	·0572	·0198	·1019	·183	·511	·0337	·035
1·024	·1156	·0384	·205	·276	·478	·0651	·0672
1·030	·1428	·0476	·254	·282	·47	·081	·0834
1·111	·220	·085	·4075	·321	·404	·1194	·1335
1·170	·2862	·0954	·508	·325	·397	·1425	·1666
1·275	·3430	·1182	·611	·296	·314	·1612	·200
1·332	·399	·133	·712	·271	·282	·1745	·2322
1·427	·458	·1527	·816	·242	·246	·1876	·267
1·49	·523	·171	·941	·227	·224	·201	·299

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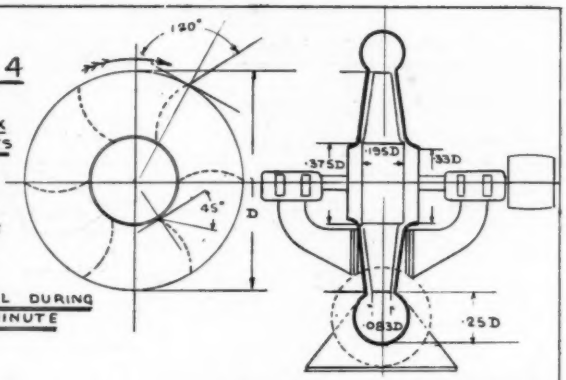
TEST SHEET Nº 4

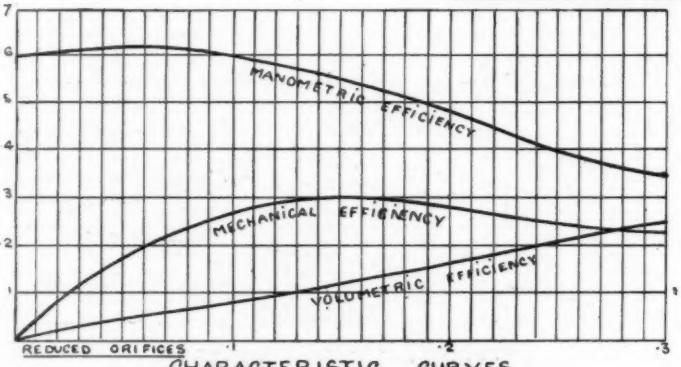
o ASSUMED COEFFICIENT OF INFLUX $=\gamma = \cdot 5$ ALL OTHER COEFFIENTS OF INFLUX AND EFFLUX ARE ASSUMED TO BE UNITY

• MECHANICAL EFFICIENCIES η_m INCLUDE FRICTION OF FAN SHAFT BEARINGS.

NOTE: TIP SPEED OF WHEEL DURING TEST = 6500 FEET PER MINUTE



CONTINENTAL CUPOLA BLOWER



CHARACTERISTIC CURVES

$\frac{C_1}{\sqrt{2gH}}$	$\frac{u_0}{\sqrt{2gH}}$	$\frac{u_1}{\sqrt{2gH}}$	$\frac{V_1}{\sqrt{2gH}}$	η_m	$\frac{gH}{C_1^2}$	$\frac{Q}{CDW}$	$\frac{Q}{DW\sqrt{2gH}}$
·916	0	0	0	0	·596	0	0
·914	·057	·020	·102	·144	·594	·036	·0334
·903	·114	·040	·204	·163	·615	·074	·0661
·910	·143	·050	·254	·242	·604	·092	·0834
·952	·231	·076	·413	·300	·550	·142	·135
·975	·286	·101	·510	·300	·526	·171	·166
1·011	·343	·121	·612	·264	·490	·198	·200
1·102	·396	·140	·705	·260	·413	·210	·231
1·16	·457	·162	·816	·228	·373	·230	·268
1·208	·515	·183	·916	·226	·343	·249	·300

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revolutions for a given water gauge are greater.

Another point of interest in this fan is the flatness of the top of the curve of its mechanical efficiency. It frequently happens that when an induced draught fan is put down, no provision is made in the fan to allow for future additions to the boiler plant. With the average fan this frequently means that the whole induced draft plant will have to be pulled out and a larger plant installed to deal with the increased volume of the effluent gases, or that for a considerable portion of its life the fan will be working at an inefficient orifice.

A similar case frequently arises in the ventilation of mines, when, owing to the enlargement of mines, more air is required at the same water gauge. It will be seen on referring to the test sheet that No. 2 fan can be arranged to handle an increased volume of air up to over 50 per cent. without any appreciable decrease in its mechanical efficiency.

A comparison between the characteristic curves of these two fans should be of considerable interest. Test sheets 3 and 4 contain tests of two fans similar in every respect except that in sheet 4 the blade tips are curved forward in the direction of rotation, while in sheet No. 3 they are curved backward. The mechanical efficiency of these two fans is low, which is partly due to the following causes:—The fans are small, and were tested at a tip speed of 6,500 ft. per minute, but were designed for a tip speed of upwards of 15,000 ft. per minute. The useful work done by a centrifugal fan varies directly as the cube of the speed, whereas the friction of the bearings probably increases directly as the speed. As the fans were designed to deliver a relatively small volume of air at a high pressure, the width of the wheel has been made comparatively narrow, and it is obvious that the friction of the sides of the fan wheel is as great as if the wheel had been twice the width.

Thus in a narrow fan the friction between the sides of the fan and the surrounding air is relatively much greater. However, the fan is more suitable than a wider fan for the purpose for which it has been designed.

Referring to test sheets 3 and 4, it will be seen that, although the forward curvature of the fan blades has the effect of increasing the volumetric efficiency of the fan at the larger orifices, the most marked difference between the characteristic curves of the two fans is the higher manometric efficiency of the latter.

The chief advantage of varying the curvature of the blade tips is found when the fan is direct driven. For instance, fans used in connection with suction gas plants are required to handle a very small volume at a considerable pressure, and as, with the small motors required to drive these fans, it is advisable not to exceed a speed of more than about 1,500 revolutions per minute, it becomes necessary to increase the diameter of the wheel in order to obtain the required suction, at the sacrifice of some mechanical efficiency. On the other hand, the possibility of varying the speed by varying the manometric efficiency often enables a stock size of motor to be used.

In conclusion, although the writer and others have designed steel plate fans without diffuser or chimney, which have given a maintained mechanical efficiency of well over 60 per cent., any claim for an ordinary commercial fan of the above type for an efficiency of much over 50 per cent. should be accepted with caution.

The majority of fans at work in this country are running at a mechanical efficiency considerably lower than the latter figure.

It should be noted that in these latter tests the co-efficient of influx was ·5, and that an increased value for this co-efficient would be accompanied by a corresponding improvement in the mechanical efficiencies of the fans.

Vanadium in Steel Castings.

The addition of vanadium to ordinary steel for castings has much more than doubled and in many cases more than trebled the breaking strength of the locomotive side frames which are now being used by several American railway companies. According to the *American Machinist*, the Union Steel Castings Co., of Pittsburg, uses the open-hearth furnace for melting its steel, and the vanadium is added to the mixture just before tapping. The slag is raked from the top of the molten metal, the ferro-vanadium thrown in and the whole allowed to stand a few minutes, so that the vanadium will thoroughly mix with the metal. The furnace is then tapped and the moulds poured.

If the castings are properly annealed after being cast, the vanadium-steel castings are more easily machined. This in itself is quite an item, as one locomotive builder has had to pay nearly twice as much for machining side frames as it would cost to machine the ordinary carbon steel.

The Manufacture of Cement and Bricks from Blast-Furnace Slag.

The following paper was presented by the Chevalier C. de Schwarz at the annual meeting of the Iron and Steel Institute. An addition to the text has, however, been made, describing the Cowper-Coles process. (Ed. *E.R.*)

TAKING the total production at all blast-furnace works in the world, according to recent statistics, at about 50,000,000 tons of blast-furnace slag for the last year, and assuming further that one ton of ungranulated blast-furnace slag measures, when broken up, about 20 cub. ft., the blast-furnace slag produced in one year represents a mountain of nearly 1,000,000,000 cub. ft. To dispose of such enormous masses yearly deserves serious consideration, taking into account that the production of pig iron, and with it also that of slag, is steadily increasing, and that the land in the neighbourhood of blast-furnaces is, as a rule, of great value.

John Payne, an Englishman, was the first who succeeded in utilising blast-furnace slag for making big solid blocks —up to three tons in weight—which were successfully used for making river and canal embankments.

According to his method of making blocks, patented in the year 1728, the liquid slag was first thoroughly worked through, by means of a shovel, in order to allow any air or gas bubbles to escape, whilst, at the same time, sand or crushed slag was added. The doughy mass thus received was pressed into cast-iron moulds lined with sand. When hard, the blocks were withdrawn from the moulds and allowed to cool down slowly in a bed of sand mixed with charcoal dust.

This method of making blocks could, however, only be used for utilising blast-furnace slag high in silica and poor in lime, *i.e.* principally for slag resulting from blast-furnaces worked with charcoal, for reasons not necessary to be explained.

BRICKS.

Fritz Lürmann, when at Osnabrück, was the first who recognised and also utilised the hydraulic properties of granulated basic blast-furnace slag for making bricks by mixing granulated blast-furnace slag with lime-cream and pressing this mixture into moulds. The lime thus combining with the free silica in the granulated slag served as a cement, and the bricks became hard on free exposure to the atmosphere within about six to eight weeks. The slag bricks produced at the beginning were, however, of inferior quality, and could, on account of their insufficient strength, only be used for masonry of minor importance.

It was also found that, during the time of hardening, a good many bricks cracked and fell to pieces.

Considerable improvements were made later on, namely—

(*a*) An automatic feeding apparatus was provided, having for its purpose the maintenance of the proper proportions between the granulated slag and the slaked lime, ascertained by experiment, instead of leaving these proportions to be adjusted, as before, by the workmen employed. In general it was found out that an addition of 150 lbs. of dry slaked lime to 850 lbs. of granulated slag, containing on an average 20 per cent. of water, answered the purpose pretty well.

(*b*) Appliances were employed, by means of which an intimate mixture between the slaked lime and the granulated slag was obtained.

(*c*) A press, especially constructed for making slag bricks, was employed. In the first instance the maximum pressure was raised to about 3,500 lbs. per square

inch. Secondly, the press was constructed in such a way as to do its work with a gradually increasing pressure, instead of, as before, by means of a heavy shock. The latter had a double advantage: firstly, the high pressure was transmitted up to the very interior of the brick, which was not the case when the press worked with a shock; and secondly, all superfluous moisture was squeezed out.

(*d*) In order to avoid, as much as possible, any loss from bricks bursting, on account of small particles of unslaked lime being entangled and inclosed in the interior of the brick, the slaked lime had, before use, to pass through a ball mill, where it was reduced to fine powder and intimately mixed, whereby a complete conversion of any free lime into hydrate of lime was ensured.

One such press with its accessories, as mentioned before, produces about 2,000 slag bricks per hour, the whole requiring about 25 h.p. to drive it.

One slag brick of ordinary size, manufactured in the way described, weighs on an average 8 lbs., and has a maximum crushing strength of 1,700 lbs. per square inch. The working expenses (lime, wages, repairs, and motive power) are stated to be about 8*s*. per 1,000 bricks of ordinary size.

A brick press, also constructed for making slag bricks, was recently invented by Paul Thomann in Germany. The peculiarity of this press consists of an improved mixing apparatus, of special construction, for mixing slaked lime and granulated slag, as well as in a peculiar method of pressing the bricks. The process is as follows:—

Slaked lime and granulated slag coming from an automatic feeder are led to the mixing apparatus by means of a band conveyor. The mixing apparatus consists of a small cylindrical sheet-iron vessel containing a mixer with screw-like arms of peculiar shape, in which the materials are, owing to quick rotation, intimately mixed within a short time.

The mixture of sand and slaked lime thus produced falls, by means of a hopper, into the brick press. The peculiarity of the latter consists in an arrangement by means of which the brick is formed in layers, each layer being hammered down separately, one above the other, until the brick mould is filled up. This arrangement has the advantage of cheaper working expenses and less initial outlay. The bricks produced with this machine are also less heavy and have a rough surface, the latter being preferred by the masons.

Another method of making slag bricks, still in use, consists in mixing one part of Portland cement with from four to five parts of granulated slag and passing this mixture into moulds. These bricks must remain in the mould for twenty-four to thirty hours after being pressed. As they are not allowed to harden in the open they have to remain, after having been taken out from the mould, for six to eight weeks in a covered shed, well protected against sun and wind, where they are moistened from time to time.

The bricks produced in this way are of very good quality, but their cost of manufacture is very high, requiring also a considerably high initial outlay; it can therefore only be recommended for making artificial stones of special size, staircase steps, slabs, &c.

The best slag bricks, so far as exact shape and dimensions as well as great hardness and resistance to crushing are concerned, are manufactured according to the English method.

According to this process blast-furnace slag can be made into bricks or stones without any addition of cement, slaked lime, or any binding medium. It is based on the fact that insoluble silica is rendered soluble, *i.e.* ready for combination, if exposed to high steam pressure during a certain lapse of time. A full description of this method of making slag bricks is already given in the *Journal of the West of Scotland Iron and Steel Institute* for 1904.

The bricks, manufactured according to this process, can be transported to their destination and used for masonry as soon as they have left the hardening

chamber, described in the above paper. For this method of manufacturing bricks blast-furnace slag from the old slag heaps, even if exposed to free air for several years, can be utilised.

The cost of producing 1,000 bricks of ordinary size, according to the English process, described before, is stated to be 13*s*.

Slag bricks have the following advantages over ordinary baked clay bricks:—

(*a*) They have a considerably higher resistance against crushing.

(*b*) Houses built with slag bricks are never damp, and can be occupied without danger to health as soon as they are built.

(*c*) Slag bricks are more accurate in shape and dimensions, because they are not baked, and therefore do not shrink like clay bricks.

For certain purposes slag bricks, manufactured according to the English process, as described before, are, on account of their accurate shape and extreme hardness, preferred even to natural stone; for instance, in Brussels such bricks are used for the facing of walls for houses (*Verblendsteine*), and paid for at the rate of 60 francs (48*s*.) a thousand. For ordinary masonry, slag bricks manufactured according to the other methods, already described, are used because they are considerably cheaper.

CEMENT.

Of considerable more importance than the manufacture of slag bricks and stones, with reference to the utilisation of slag, is the manufacture of cement. This is principally due to the fact that cement, weight for weight, sells at a rate which is about four times as high as that of bricks.

The subject of the utilisation of blast-furnace slag for making cement has already been treated in detail in the author's previous papers, read before this Institute in 1900 and 1903, and before the International Congress of Mining and Metallurgy at Liège in 1905, to which he would refer.

Since then the same question has been treated by several authorities, such as Dr. Passow, Le Chatelier, Wedding, Blount, Thwaite, Day, A. Sheperd, Tantzen, Jesser, Baron Jüptner, Ast, Lünge, Hofer, Struthers, Zulkowsky, and others, who have written about it in different professional papers and pamphlets. The author cannot quite agree in some cases with the statements made. For instance, it has been repeatedly stated that no cement can be made from slag resulting from the manufacture of white pig iron. This is incorrect, as may be proved by the fact that Portland cement of good quality can be made from such slag, containing 42 per cent. of lime and 4½ per cent. of oxide of manganese. The cement made from such slag showed not the slightest trace of instability of volume even after six years' use; it also stood all the tests required by the standards for Portland cement. The manganese oxide in the cement gave it a somewhat brownish colour, which, however, was not considered a fault by some customers, but on the contrary was preferred to the ordinary tint for making artificial stones.

To a certain extent the presence of metal oxides, such as those of iron and manganese, which, as a rule, are higher in slag from white pig iron, makes the cement made from it more apt to resist the influences of sea water, as already mentioned in previous papers. Secondly, the presence of metallic oxides reduces the temperature of fritting, necessary for the formation of clinker, thus effecting saving in fuel as a consequence. As the majority of blast-furnace slag produced nowadays results from white Thomas pig, it may be considered advisable to draw attention to this fact, as hitherto the general belief was that only slag resulting from grey pig can be used for making cement on account of its higher percentage of lime and its small percentage of manganese oxide. It has been proved that a high percentage of lime in Portland cement is not only not necessary, but is to a certain extent even injurious, as, being to a certain extent free, it causes the

cement to "blow." Therefore such cement, rich in lime, must, as every experienced cement maker knows, be kept for some time in a cement silo before being ready for use, in order to give it time and opportunity to absorb carbonic acid and water from the air for the purpose of converting the free lime it contains into carbonate of lime and into hydrate of lime respectively. Experience has also shown that cement, rich in lime, cannot be used advantageously for buildings in sea water.

A new process of making cement from blast-furnace slag has been invented by Professor Mathesius at Charlottenburg. This process is based on the principle, already referred to, that insoluble combined silica can be turned into the soluble, combinable state by exposure to high steam pressure. The process is described as follows: The blast-furnace slag is allowed to cool down, when it is put into boilers, where it is exposed to steam pressure until it is reduced to powder. Results of experiments have proved that slag, thus treated, had acquired hydraulic properties, but nothing has been done as yet to start works on a commercial style.

Mr. Renfert, starting on the same principle, took out a patent according to which granulated blast-furnace slag was treated with steam, but subsequently mixed with lime. This mixture being ground to a very fine powder, yields a cement of very superior quality. Notwithstanding, after experimenting for some time, the inventor abandoned his process on account of too high working expenses.

Mr. Canaris invented a process according to which hot liquid blast-furnace slag, containing not less than 40 per cent. of basic matter, is cooled down suddenly by mixing it with thin lime-cream. The product thus received is then ground into powder, and after that supposed to be cement. This process has some resemblance to the Wolff and Lessing process, already described in my paper read before this Institution in 1903. Neither the "Canaris" process nor that of Wolff and Lessing have found their way into practice, and will hardly ever do so.

Timm, Hayn, and others have invented different arrangements for granulating slag without water, but, none of them having been carried out in practice, no opinion can be given about them.

Of all the processes of making cement from blast-furnace slag invented recently, it appears that only one of them has as yet been accompanied with success, namely, the "Colloseus" process, called so after the name of the inventor.

According to this process, solutions of alkaline salts are injected into the hot liquid and thus intimately mixed with the latter, the nature and concentration of the injected solutions depending on the chemical composition of the slag, principally on its contents of lime. The quantity of the solution to be injected should be as high as possible; however, the slag thus treated must be perfectly dry after the operation. The salts used for preparing the solutions are principally alum, sulphate of magnesia, and nitrate of lime. The concentration, as a rule, varies from ·2 to 5 per cent. of salt to from 95 to 98 per cent. of water.

On account of the great heat the salts are decomposed, most of the sulphur escaping as sulphurous acid and sulphuretted hydrogen. The slag is chemically and physically changed, and gets the appearance of a porous clinker easily broken up and reduced to powder.

In case slag with a comparatively high percentage of silica and a lower percentage of lime is to be converted into cement, the concentration of the alkaline solution is raised to a maximum of 10 per cent. of the salt to 90 per cent. of water; besides this a small addition of common cement, clinker rich in lime, has been found beneficial in such cases.

At the beginning the "Colloseus" process did not prove successful, principally on account of deficient construction of the granulating apparatus, which did not allow of an intimate

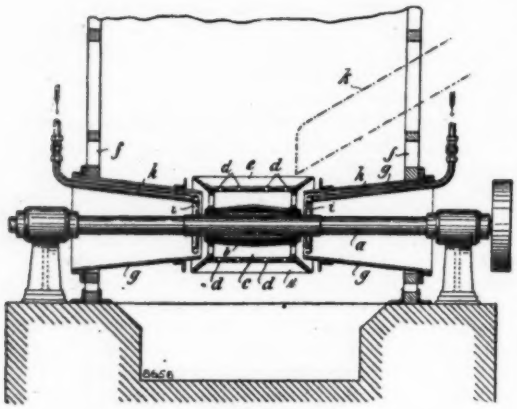


FIG. 1.

mixture between the solutions and the slag. At the same time the selection of the blast furnace where the first apparatus was put up was not a very fortunate one, as it suffered continually on account of interruptions ; besides this there was not sufficient space, and other inconveniences. Under these circumstances it was impossible to produce cement of a satisfactory or regular quality.

Lately, however, these deficiencies have been overcome by employing an improved apparatus, which the following description and drawings will serve to explain :—

Fig. 1 represents a longitudinal and Fig. 2 a cross section of the apparatus. The drum *b* fixed on the shaft *a* is divided into six interior partitions by means of cast-iron ribs *c*. On the outside the drum is provided with a number of other radial ribs *e*, running like the former, parallel with the shaft *a*. Between the ribs *e* a number of longitudinal openings *d* are arranged to provide communication between the interior and the outside of the drum, the latter revolving at the rate of about 650 revs. per min. On this drum the hot liquid slag coming from the blast furnace, is led by means of a channel *k*, the whole apparatus being enclosed by a chamber or casing *f*, made of sheet-iron and cooled by water from the outside.

Two funnels *g* (Fig. 1) fixed on the casing *f* contain the tubes *h*, the latter leading the alkaline solutions to the revolving drums. At the same time through these funnels cool air is sucked into the interior of the drum along with the alkaline solutions and the quick revolving drum acting like an exhauster, propels them together through the openings *d* with a certain force. In order to ensure a proper distribution for the entrance of the solutions into the interior of the drum, two ring tubes *i* (Figs. 1 and 2) perforated with little holes (shown in Fig. 1) are provided.

The slag, being thus intimately mixed with the alkaline solution, is hurled with great force against the casing *f*, from which it falls by means of an incline into little bogies to be transported to the crushing mills. From this description it may be seen that the working expenses for making cement from blast furnace slag according to this process must be exceedingly low, and the initial outlay for erecting such cement works very moderate, as the drying and grinding of raw materials, as well as brick making and the burning of clinker, is avoided.

As to the quality of this cement, it may be said that, according to information received, it has stood all the tests prescribed for Portland cement by English, French, and German authorities. The cement has been employed for about a year in the erection of viaducts, railway embankments, bridges, houses, &c., showing, up to date, not the slightest trace of damage.

It has several times been pointed out as a drawback to the utilisation of blast-furnace slag, that the latter is more difficult to grind than natural raw materials. This reproach is, to a certain extent, justified, although this difficulty is already largely overcome by

granulating the slag, whereby the latter, being cooled down very suddenly, becomes exceedingly brittle.

In addition to this, crushing mills have been recently invented specially well adapted for grinding slag and have proved a great success in practice. The ball-mill, with air separator invented by Mumford & Moodie, and made by the Brothers Pfeiffer at Kaisershautern in Germany, affords an instance of such a mill.

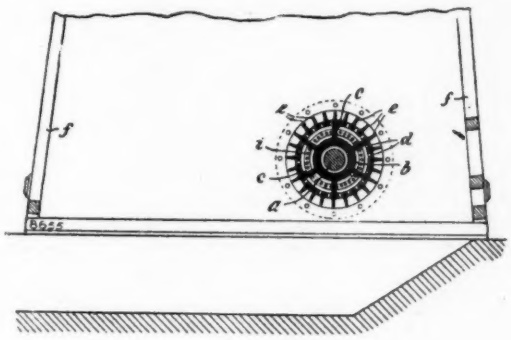


FIG. 2.

The following is a description of this apparatus: Fig. 3 represents a vertical section through the air separator, the latter representing, as it were, the backbone of the whole arrangement; *g* is an exhauster, fixed, like the two discs *b* and *d*, on the quickly revolving vertical shaft *a*. The ground material (raw meal or cement) coming from the ball-mill drops into the funnel *f*, and from there on to the disc *b*, from where, by means of centrifugal power, it is hurled against the ring *c*. From there it falls on a second disc *d*, the latter being of greater diameter than the former. From this disc, again, the material is hurled towards the ring *e*. This arrangement has for its prime purpose to distribute the material as much as possible in the air enclosed by the rings *c*, *c* and *e*.

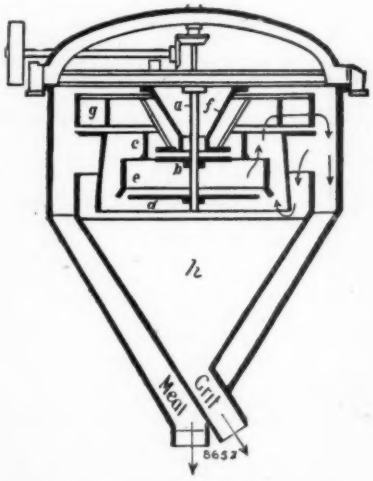


FIG. 3.

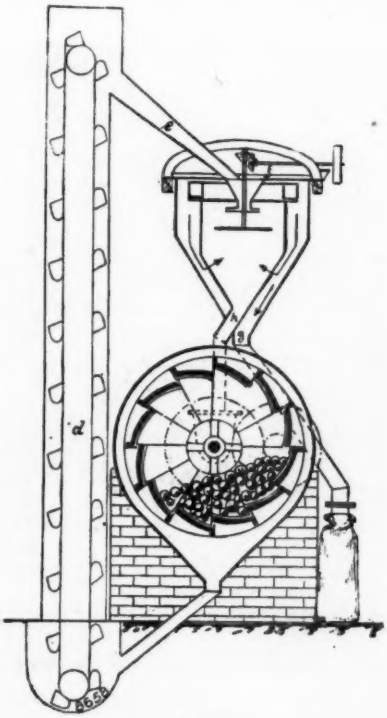


FIG. 4.

Through the ring *e*, which is open below, the air is sucked on by the exhauster *g*, and enters the interior of the two rings *c* and *e*, as shown by arrows, taking the fine, finished material along with it, which, after having been passed through the exhauster *g*, enters the chamber enclosed by the outer casing and drops, as shown by arrows, out of the apparatus to be transported to its destination, while the air, being sucked up by the exhauster, re-enters the chamber enclosed by the two rings *e* and *c*. The unfinished material, or grit, drops from the lower disc *d* into the funnel *h*, and thence into the crushing mill to be ground again.

This arrangement has been found very convenient and economical, as all the slag which is ground fine enough is separated and carried away to its destination instead of being unnecessarily ground over again and again, as is done with the so-called tube finishing mill, the latter thus causing loss of time and driving power.

Fig. 4 shows the arrangement of a complete set, consisting of a ball-mill, air-separator, and elevator. They are manufactured in different sizes for a production of from 1 to 9 tons of finished material per hour, leaving about 12 per cent. of residue on a sieve with 30,000 meshes per sq. in.*

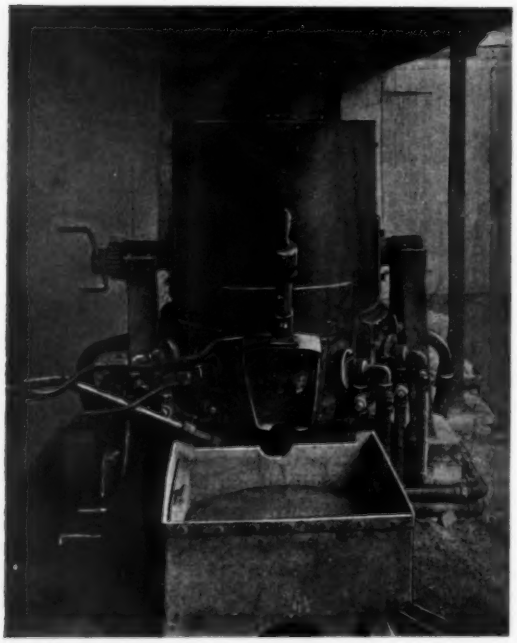


FIG. 5.

CONCLUSIONS.

From what has been said it may be correctly concluded that blast-furnace works, especially those producing grey pig, have still a large field for improvement by utilising their slag in the way described, especially for making cement.

With reference to the question of getting a market for the cement, attention is to be drawn to the fact that it can be manufactured at considerably less expense than common Portland cement, and that therefore it can undersell the latter on the market.

It may also be mentioned that

* The "Cowper-Coles" process for making cement equal to Portland cement direct from blast furnace slag consists of taking the slag when still molten and raising the temperature by means of an electric resistance furnace, during which period the necessary quantity of chalk is added, and then subjecting the whole to electrolysis, which brings about certain reactions producing a cement equal to the best Portland cement at a very small cost compared with the present methods.

The illustration shows a furnace built after the principle of the cupola furnace, into which the molten slag can be run direct from the blast furnace or old slag reheated. The front of the furnace, as will be seen from the illustration, is provided with electrodes between which the molten slag passes, the desired quantity of chalk being added by means of an automatic feed. After being electrolysed the molten slag is run on to a revolving disc and ground to the necessary fineness.

the consumption of cement is steadily increasing in a comparatively high proportion, because the employment of reinforced concrete instead of brick or stone, or of iron constructions, for buildings of all sorts, for bridges, viaducts, &c., &c., extends more and more. It may also be mentioned that the value of cement imported into countries beyond the sea represents the sum of about 1¼ million pounds a year.

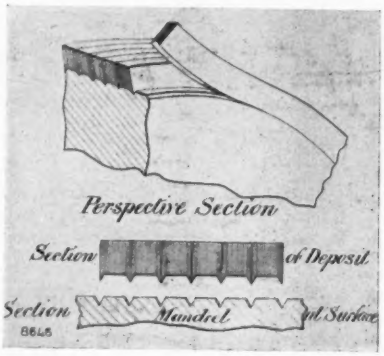
That Portland cement made from blast-furnace slag has been employed for buildings, bridges, fortifications, railway embankments, &c., as well as for buildings in sea-water for the last fifteen years, without showing the slightest injury after so long a period, is proof enough that any prejudices against its use are thoroughly unfounded.

A New Process for the Manufacture of Copper Wire.

Mr. Sherard Cowper-Coles has invented a new system of producing copper wire in one operation from crude copper such as Bessemerised copper bars. The copper is electro-deposited on a revolving mandril or drum at a critical speed, which speed was originally determined by rotating a cathode in the form of a cone, that portion of the cone which gave the smoothest and toughest deposit being the critical speed for the conditions under which the copper was deposited. Very dense copper is produced of considerably higher tensile strength than can be obtained by the ordinary process of annealing, and drawing or rolling.

The theory of the process is that each molecule of copper as electro-deposited is burnished or rubbed by the friction of the electrolyte on the mandril, insuring a more homogeneous metal than is obtained by applying great pressure to a large mass of metal by swaging, rolling or drawing.

Copper electro-deposited crystallises at right angles to the surface on which it is deposited; this fact has been turned to account by making a spiral scratch, which must be V-shaped, on the mandril so as to cause the crystals to make a weak line of cleavage. If the scratch is rounded at the base the crystals form radially and no weak line of cleavage is formed. Four or five miles of wire can be made on a mandril; the strip is unwound and passed through a



NEW PROCESS FOR THE MANUFACTURE OF COPPER WIRE.

set of dies to remove the burr or fin and form a round section.

We understand that a plant is now in course of completion on the Continent for working this process on a large scale.

Chloride of Barium for Hardening.

While the lead bath can be used for heating high-speed tools, and may be very useful in the case of small ones, it does not prevent entirely the trouble of oxidation. None of the other metals available for metallic baths are any more suitable.

A partial solution of the problem was found when barium chloride was tried. The chloride melts at a temperature somewhat below that best adapted to hardening high-speed steel, and can readily be raised to the proper temperature in a suitably designed furnace. A piece of steel when heated in a bath of barium chloride and then withdrawn is coated with a thin film which effectually preserves it from contact with the air until it is plunged into the cooling bath or cooled in the air blast.

The process has recently been taken up and developed by the Firth-Sterling Steel Company, U.S.A.

As now used it is exceedingly simple. Commercial barium chloride, which sells for about 1½*d.* a pound, is melted in a graphite crucible and brought up to a temperature of about 2,150° F. in a gas furnace. A small proportion of sodium carbonate (soda ash) is added in order to prevent fuming, and the bath is ready for use. —*American Machinist.*

"Coalesine" Fuel from Refuse.

By HERBERT G. COALES, A.M.Inst.C.E., F.S.I.

The method of disposing of ashbin refuse developed by the author is the outcome of experiments conducted by him last year at Market Harborough. Not only are the sanitary advantages attaching to the method of disposal by dust-destructors secured, but the claim is made that the briquettes can be profitably employed as fuel for works' boilers. (Ed. *E.R.*)

THE contents of the household ashbin has received the misnomer "refuse." The definition of "refuse" usually understood is, "that which is refused or rejected as useless—waste matter." But, if a little consideration be given to the matter, it will be found that the contents of an ashbin has a calorific value, therefore it is not useless, but, on the other hand, it is of use as a fuel and it is wasteful not to utilise it as such. One readily recalls instances of substances in the past being rejected and treated as waste, which now in a more enlightened and scientific age are of great value to commerce and mankind, for instance—tar, coal dust, bones, metal and shop dust.

It is, of course, quite possible for a material to be useless in a crude state, but useful if converted into another form. A lump of clay for instance is not very useful by itself in a crude state, but when converted into a pipe or a brick its character is changed into a valuable article of commerce. So with ashbin refuse, it has a value even in its crude state, but after treatment as hereinafter described it becomes a marketable commodity of considerable value.

ABOLITION OF ASHTIPS.

It has been stated lately that refuse dumped in Rome centuries ago is to-day a source of contamination. The practice of refuse tipping to-day is comparable to the old system of throwing slops out into the streets, there being nothing to recommend it except that it is cheap and nasty. The day cannot be far distant surely when it will be illegal to build up nurseries for microbes, rats and flies by tipping refuse and deliberately fouling underground water and vitiating the air. An intelligent visitor from Mars, called in to settle the refuse disposal difficulty, would certainly condemn tipping, and no doubt after a statesmanlike survey of the conditions would be amazed that sensible beings had not utilised matter which had a calorific value, and so cleansed by fire (at a profit) the refuse made by a community.

CONVERSION OF REFUSE INTO FUEL.

There are two main factors in favour of converting refuse into fuel.

1. Crude refuse is a nuisance which may be abated by subjection to fire.
2. Crude refuse is a fuel which may be utilised in the production of heat.

When, therefore, hygienic and commercial considerations go hand in hand, there seem grounds for venturing the suggestion that a satisfactory and profitable solution of the disposal of house refuse has been advanced. Fuel from refuse "is twice blessed" as Shakspeare said of mercy, for whilst the offensiveness of crude refuse is being dispelled valuable units of heat are generated.

"COALESINE" FUEL.

The suggested treatment referred to in this paper is the conversion of ashbin refuse into "coalesine" fuel. The process is a very simple one. The crude

"refuse," to keep to the accepted misnomer, is—

1. *Pulverised.*

To reduce it to a uniform fine material.

2. *Mixed with tar compounds.*

(a) To deodorise the material.
(b) To provide an agglutinate.
(c) To enrich the fuel.

3. *Pressed into briquettes.*

(d) To convert into convenient form for handling and storage.
(e) To give good form for combustion.

Until the Patent Lightning Crusher Company, of Southwark, invented the dust manipulator, it was a matter of impossibility to reduce the incongruous untidy contents of ashbins into one uniform material of a finely pulverised character. Attempts have been made in the past to pound refuse into a powder and also to grind it in a mortar mill, but sardine tins, old sacking and other tenacious substances do not lend themselves to being made into powder by such means.

However, the dust manipulator (with its 50 lb. hammers revolving at the high speed of 1,000 revs. per min.) instantly converts such obstinate items as those mentioned above into a fine material resembling garden mould in appearance.

The refuse in its pulverised condition can be mixed with tar or other deodorising ingredients until thoroughly incorporated. Crude ashbin refuse cannot of course be adequately deodorised (or briquetted) by reason of its varied and ragged composition. It is obvious that to increase the value of the fuel the added deodoriser should also have a calorific value: a tar deodoriser has such a value.

Assistance to the value of the fuel is obtained by selecting an agglutinate of superior calorific nature. It so happens that tar, besides being a good deodoriser, is a good agglutinate too. This fact is a most fortunate coincidence, as it simplifies and cheapens the process of fuel making.

One pound of crude refuse is capable of evaporating from 1 to 2 lbs. of water. One pound of tar is capable of evaporating about 11 lbs. of water. It is evident, therefore, that an admixture of tar with the refuse greatly enhances the calorific value of the latter. Tar has been known to be a first-class fuel theoretically, but in practice there has been always the difficulty of the tar escaping unconsumed through the fire bars when heated, and in addition there has been the smoke difficulty. In "Coalesine" fuel only so much tar is used as is necessary to deodorise and agglutinate the pulverised refuse, and in such proportion all the tar is effectually consumed without causing a smoke nuisance. The amount of tar used roughly increases the calorific value of poor refuse by 100 per cent., and in the case of good refuse by 50 per cent.

Having by the addition of tar deodorised, agglutinated and enriched the pulverised refuse, it is possible now to press the transformed fuel into suitable briquettes. The fuel, if used in bulk, would tend to smother the fire in the furnace and cause smoke, whereas in the form of briquettes a good draught is induced in the interstices naturally occurring which leads to perfect combustion. In the form of briquettes too, the fuel is easily handled and conveniently stored. No nuisance arises from the converted ashbin refuse, and a transformation has been effected as great as the production of clean glue from offensive bones, or bar soap from offal fat.

COST OF PLANT AND MANUFACTURE.

The approximate initial cost of plant, including crusher, mixer, briquette press and power, to convert 10,000 tons of ashbin refuse per annum into "Coalesine" fuel would be about £2,000.

The approximate average cost of converting ashbin refuse into "Coalesine" fuel, including labour, power, ingredients, wear and tear, and loan charges would be about 4*s.* a ton.

CALORIFIC VALUE OF "COALESINE" FUEL.

The approximate calorific value of "Coalesine" fuel is one-third that of best coal, 1 lb. of the fuel evaporating 3 lb. of water or thereabouts.

"Coalesine" fuel having an evaporative power of one-third of best coal, and costing 4*s.* a ton to produce, it follows that where best coal is less than 12*s.* a ton, a profit cannot be shown in favour of "Coalesine" fuel, although the hygienic object would have been attained by burning. But where best coal is more than 12*s.* a ton it becomes remunerative, as well as hygienic, to burn "Coalesine" fuel.

The following table sets forth the value of "Coalesine" fuel in comparison with two grades of coal:—

A = Best coal, 1 lb. evaporating 9 lbs. of water.

B = Poor coal, 1 lb. evaporating 4½ lbs. of water.

Relative number of lbs. of water evaporated per lb. of fuel.		Comparative heating value of "coalesine" to coal.		Relative value of "coalesine" to the cost of its own production (viz., 4*s.* a ton) where coal costs per ton:									
Crude refuse.	Coalesine.	*A.* Best coal.	*B.* Poor coal.	6*s.*	9*s.*	12*s.*		15*s.*		18*s.*		21*s.*	24*s.*
				B.	*B.*	*A.*	*B.*	*A.*	*B.*	*A.*	*B.*	*A.*	*A.*
				s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
1	2¼	·25	·50	3 0	4 6	3 0	6 0	3 9	7 6	4 6	9 0	5 3	6 0
1¼	2½	·28	·56	3 4	5 0	3 4	6 8	4 2	8 4	5 0	10 0	5 10	6 8
1½	2¾	·31	·62	3 8	5 6	3 9	7 6	4 7	9 2	5 6	11 0	6 5	7 4
1¾	3	·33	·66	4 0	6 0	4 0	8 0	5 0	10 0	6 0	12 0	7 0	8 0
2	3¼	·36	·72	4 4	6 6	4 4	8 8	5 5	10 10	6 6	13 0	7 7	8 8

Take, for example, a town where 1 lb. of ashbin refuse will evaporate 1¾ lb. of water and best coal is 21*s* a ton, then 1 lb. of "Coalesine" fuel will evaporate 2¾ lbs. of water and have a relative value to the cost of its own production (viz., 4*s.* per ton) of 6*s.* 5*d.* per ton, or a credit balance of 2*s.* 5*d.* per ton. Or, taking another example, where 1 lb. of refuse will evaporate 1¼ lbs. of water, and poor coal is 12*s.* a ton, then 1 lb. of "Coalesine" fuel will evaporate 2½ lbs. of water and have a relative value to the cost of its own production of 6*s.* 8*d.*, or a credit balance of 2*s.* 8*d.* per ton.

CONSUMPTION IN WORKS BOILERS.

The "Coalesine" briquettes could be burned in ordinary works' boilers without the erection of special furnaces, or could be consumed for steam raising at municipal works such as at electric lighting or pumping stations.

The calorific value of the briquettes would be fairly uniform by reason of the steadying effect of the tar. Where required to raise steam at a faster rate the furnaces could be fortified with coal in addition to the briquettes without in any way detracting from the object in view.

With the exception possibly of enabling the authority to deliver the refuse at a more central site the means of collection and cartage would not be interfered with, the cost of manufacturing the fuel briquettes being estimated from the time the refuse was tipped at the depot, as in the case of a refuse destructor.

ALTERNATIVE DISPOSAL OF PULVERISED REFUSE.

Where a demand occurred at certain seasons of the year for a fertiliser for the land, the briquette making could be suspended for a time, and the pulverised refuse could be disposed of as is done already by the borough of Southwark.

The Limiting Speed of Vehicles moving on Curves, and the Effect of the Gyrostatic Action of the Wheels on Stability.*

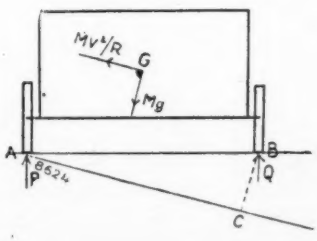
The recent terrible accident at Salisbury Station in which twenty passengers of an express train were killed through the capsizing of the locomotive, directed attention to the question of the stability of vehicles on curves. For there can be no doubt that the accident was caused by taking the curve at too high a speed; the locomotive simply fell over on its side on the outside of the track. The accident at Grantham, also, was probably due to a similar cause. In that case, derailment took place after the curve beyond the station had been passed; but possibly oscillations were set up on the curve which produced disastrous effects a little further on when the super-elevation had ceased.

The frequency of accidents through the skidding of motor cars when turning corners, or when suddenly changing the direction of running is only to be explained by an insufficient appreciation, on the part of those in charge, of the conditions of stability of vehicles when turning. In my opinion, corners are habitually turned far too quickly by motor cars for the safety not only of the public, but of the persons in the cars. It ought to be remembered that people of different ages and of very different degrees of activity and presence of mind are continually crossing, and are entitled to cross in safety, at such places; and likewise that ordinary streets and roads are not sloped, as a specially constructed track always is, inward towards the centre of the curve, so as to diminish the tendency to capsize outwards, which always arises when the vehicle is taking a curve.

* Professor Andrew Gray, L.L.D., F.R.S.—Proceedings of the Royal Philosophical Society, Glasgow.

The dynamical theory of this matter, so long as the gyrostatic action of the wheels and other rotating parts is not taken account of, is very simple. I have thought that perhaps a short rediscussion of the subject, so as to include a determination of the gyrostatic effect of the wheels of the locomotive, an effect which has been referred to by various people as probably an important factor, would not be altogether needless at the present time.

In order to put down the theory, suppose that in the figure AB represents the position of a cross-section of the wheel-base of the vehicle, so that BC is the super-elevation h of the track of the wheels on one side, the outer, let us say, above the track on the other side; that G, the centre of gravity of the vehicle is at a distance d from the wheel base, that $2b$ is the distance from the centre of one track to the centre of the other, and that θ is the angle BAC. We shall suppose that P and Q are the reactions of the rails (or ground) on the two sets of wheels, as indicated on the figure, and that V is the speed of the vehicle, R, the radius of the curve, say the radius of a line midway between the two tracks, and Mg the weight of the vehicle. We have by the diagram, taking moments first about B, then about A, for the two forces P, Q, and weight Mg, and equating the sum of moments about the same point, of the rate of change of momentum MV^2/R (which is directed



inward from G towards the centre of the curve) we get

$$2bP = M\left\{g(b\cos\theta + d\sin\theta) - (d\cos\theta - \tfrac{1}{2}h)\ \frac{V^2}{R}\right\}$$

$$2bQ = M\left\{g(b\cos\theta - d\sin\theta) + (d\cos\theta + \tfrac{1}{2}h)\ \frac{V^2}{R}\right\}$$

But $\cos\theta = \sqrt{4b^2 - h^2}/2b$, $\sin\theta = h/2b$, and therefore the equations just written become

$$4bP = \frac{M}{Rb}\left\{gR(b\sqrt{4b^2-h^2} + hd) - (d\sqrt{4b^2-h^2} - hb)\ V^2\right\}$$

$$4bQ = \frac{M}{Rb}\left\{gR(b\sqrt{4b^2-h^2} - hd) + (d\sqrt{4b^2-h^2} + hb)\ V^2\right\}$$

From these expressions the force on the rail or the ground exerted by the wheels on either side can be found. Also, by putting P equal to zero, we can find the value of V for which the inner wheels just cease to press on the rail or ground.

The following are approximately the forces for a locomotive similar to that of the Salisbury accident. For that engine the distance $2b$ was 59 in.; the height of the centre of gravity above the wheel base was also 59 in. nearly; the weight of the engine was 52·2 tons with water in the tubes and men on the footplate. The radius of the curve at Salisbury was 528 ft., and the super-elevation of the outer rail 3·5 in. The following table gives the forces on the rails of this curve for the speeds mentioned:—

Speed, Miles per Hour.	Inner Rail.	Outer Rail.
30	23·9 tons	29·3 tons
40	19·3 ,,	33·9 ,,
50	13·4 ,,	39·8 ,,
60	6·2 ,,	47 ,,
67·3	0 ,,	53·2 ,,

The super-elevation of the outer rail, which would just give zero force on the inner rail for different speeds are shown in the second table.

Speed 15 Miles per Hour.	Super-elevation. 27 inches.
30	− 21 ,,
40	− 17 ,,
50	− 9·3 ,,
60	− 2 ,,
67·3	+ 3·5 ,,
70	+ 5·2 ,,
80	+ 14 ,,

Of course, when there is zero force on the inner rail the state is one of extreme danger, and the speed should fall far short of that which throws all the weight on the outer rail. The speed of 30 miles an hour, at which there are five parts of the weight on the outer rail and four parts on the inner, is probably high enough. For it is to be remembered that transverse oscillations of the engine are inevitably set up which produce alternate increase and diminution of the weight on either rail, and that if the speed is so very high as to even approach the critical value (that which makes the force on the inner rail zero) the equilibrium will be endangered by every oscillation set up. And if it happen that a considerable oscil ation, set up by any cause, is so timed as to chance to be assisted by some other disturbance, the equilibrium may be destroyed, and capsizing or derailment take place.

It will be observed that I have not discussed the effect of the parallelism of the axles of the driving and trailing wheels, which renders pure rolling of the wheels on both sides impossible. The engine has no differential gearing like that provided in a motor car; and, besides, in the case of a six-coupled locomotive the differential wheels overlap the rails to different extents. All these things must conduce to the production of oscillations, which might be a source of serious danger at speeds even considerably below the critical speed.

I may say here that there can be no doubt that the contention always put forward in letters to the newspapers when a locomotive is derailed on a curve, that the flanges on the wheels are not sufficiently deep, is without real force in almost any case. It is true that with increase of size and weight of locomotives the depth of the flange has not increased; but no flange, however deep, could be of the slightest use in preventing the inner wheel of the locomotive from leaving the rail on a curve.

With regard to the gyrostatic action of the wheels, it may merely be stated that the capsizing torque on the carriage or locomotive brought into play by this cause, is $\mu\omega\phi$, where μ is the total moment of inertia of the wheels about their axes, ω the angular velocity of their rotation, and ϕ the angular velocity with which the carriage is moving round the curve. If r be the radius of a wheel, and R the radius of the curve

$$\omega = \frac{V}{r},\ \phi\ \frac{V}{R}$$

so that the torque is $\mu V^2/Rr$.

For the locomotive which capsized at Salisbury, the total moment of inertia of

the driving and trailing wheels may be estimated as 34, taking a ton as the unit of mass, and a foot as the unit of length. Thus we obtain for the torque approximately the value $34V^2/3{\cdot}35\times528$. For 60 miles an hour V is 88 ft. per sec., and thus we obtain for the torque, in the units indicated, $34\times7744/3{\cdot}35\times528$.

We must take account of this in the equation of equilibrium. Denoting the torque $\mu V^2/rR$ by L, the equation for $2bP$, given above is at once modified to the proper extent by subtracting L from the right hand side. The final result when L is taken into account is

$$V^2 = 32 \times 528 \frac{33}{57{\cdot}25 + 2{\cdot}25}$$

as against

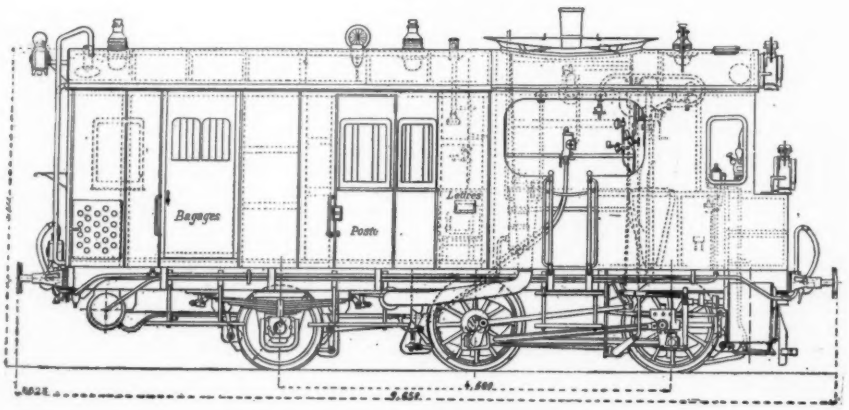
$$V^2 = 32 \times 528 \frac{33}{57{\cdot}25}$$

This is a diminution of about 4 per cent. on V^2 or 2 per cent. on V. The critical speed is thus only diminished from about 67·5 miles an hour for the Salisbury curve to 66 miles an hour. The gyrostatic capsizing action is, therefore, comparatively trifling in amount, and need hardly be reckoned with, when a proper margin of speed safety is maintained. It is to be noted, however, that it diminishes the safety. The smallness of the effect renders it unnecessary to calculate the moment of inertia of the wheels more exactly than was done for the estimate given above, which is very rough.

Steam Motor Postal Cars for the Italian Railways.

The postal equipment of the Italian railways has recently received a useful and interesting addition in the shape of several steam motor mail vans, with the object of improving and accelerating the postal services.

The accompanying outline drawing, for which we are indebted to *Le Génie Civil*, will serve to give some idea of the appearance of these vehicles which, it may be mentioned, were constructed for the Italian railways by Messrs. Borsig, Berlin. As will be seen, the carriage is divided into three compartments. The first is occupied by the power equipment, a vertical fire-tube boiler, space for one ton of coal and 2,200 litres of water; the second is a sorting compartment, and the third is arranged for the accommodation of the mail bags and parcels. The latter is also provided with a bench and table for use of the attendants during waits, etc. A dog compartment is also provided. The three compartments open into a corridor. Access is provided by doors and movable footboards, which require to be folded up before a departure is made, owing to the width of the vehicle (2 m. 90). The overall length between buffers is 9·65 m., and that of body 8 m. 50. It is carried on three axles, and the total wheel base is 4 m. 60. The two leading wheels are coupled with the driving wheels, and are connected with the frame through the axle boxes and laminated springs. Equaliser levers are also fitted



STEAM MOTOR POSTAL CAR FOR THE ITALIAN RAILWAYS.

The rear pair are simply carrying wheels, and attached to the frame in the usual manner. The diameter of the driving wheels is 1·115 m., that of the carrying pair 1·01 m.

The frame is of steel and carries the front and a pair of cylinders, 290 mm. by 400 mm. Steam distribution is by piston valves and "Heusinger" gear. The boiler, which is of the vertical, fire-tube type, contains 366 copper tubes, providing a heating surface of 58 sq. m.; the grate area is 1 sq. m., and working pressure 13 kg. per sq. centimetre. Empty, the vehicle weighs 26·850 tons, and in running trim 31·5 tons. This weight is distributed among the three pairs of wheels as follows: driving wheels, 12·29 tons; coupled wheels, 7·61 tons; trailing wheels, 11·6 tons.

Steam heating apparatus is fitted, and a compressed air brake that can be actuated from any one of the three compartments.

Land Slips in Railway Work.*

Land slides occurring in cuttings during construction and later, are oftentimes caused by surface ditches, giving the water an opportunity to enter the ground instead of draining it off to the sides. After the water once enters the slopes, it is very difficult to drain them, and every rain will have a tendency to increase the difficulty. At the west entrance to the Oregon Short Line tunnel in Idaho, where the sides broke off vertically and heaved the track at times to such an extent as to seriously interrupt and delay the handling of material from the tunnel, the writer applied with good results horizontal bracing, in the manner shown in Fig. 1.

The most remarkable slip was encountered on the White River Railway, at the entrance of a tunnel 2,650 ft. long, its magnitude precluding all thought of removing it. The disturbance first manifested itself at what might be termed a sidehill cut. In removing the footing, the mass of clay seemed to lose its hold on the rock whereon it rested. It began breaking off, first showing cracks insignificant in size and their location being confined to the right-of-way, but later reaching far out into the adjoining hills, bringing down trees and forming breaks in the surface 15 to 25 ft. in height and perpendicular in appearance. The tunnel penetrates a sag in the mountains, consisting of a so-called boulder formation, lime and rock being found intermixed with clay, a hydrated silica of alumina of brownish colour, due to

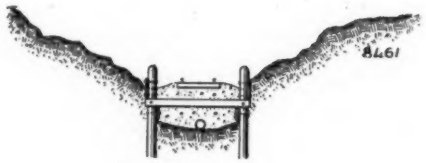


FIG. 1.—METHOD OF BRACING A CUT IN SLIDING MATERIAL.

the presence of iron oxide. This clay is very plastic, especially in the approaches, where the action of water is not constant as in a tunnel. Here the layer of clay was from 5 to 100 ft. thick, underlaid with strata of solid rock of smooth surface and slanting at an angle of from 5 to 10° toward the creek along which the line had been located, then in course of construction. The grade of the roadbed entered the rock 20 ft. below the surface; in other words, the approach to the tunnel had a 20-ft. rock cut with clay in the slope overlying it.

As soon as cracks appeared on the surface extra precautions were taken against surface water. The surface ditches were given steeper grades, and, where possible, the bottoms were cemented so that the water could drain off more quickly, thus reducing chances of penetration to a minimum. In spite of this the ground continued to break and started to move toward the open cut, at first dropping into it a little at a time. It gradually increased, until after a rather heavy rain the entire cut was filled, involving an expenditure of 4s. per cub. yd. for its removal. Though the moving masses had adopted a slope of nearly 1 on 2, the breaks continued, stretching for more than 150 ft. into the hill above the grade of the roadbed, and over 500 ft. distant from same.

To prevent similar occurrences after the road was in operation, the writer had the rock cut arched over for a distance of 600 ft. from the portal of the tunnel. An arch, framed of timber, without protection against "side pressure," cannot be relied upon as a permanent safeguard against slides. To make it serve, however, should the mass continue to move, the clay bank was removed for a distance of 12 ft. from the edge of the rock cut, and holes were drilled into the rock 8 to 10 ft. in depth, and from 10 to 15 ft. apart, in a row along the foot of the clay slope, shots being placed therein and fired simultaneously. The rock was broken but not scattered, a trenchlike crack appearing at the surface. Logs were then cut and placed alongside each other with the butt end in the rock crevices, the other end overhanging the timber arch, and resting upon

its top (Fig. 2). The material under the logs and between the logs and the arch was tamped, thus forming a solid flooring over which the material could slide, distributing it over the entire arch and serving as a weight instead of a thrust.

The further object of cracking the rock was to permit the water coming through the clay to escape, thus leaving the footing dry and in better position to act as a support. The plan worked very satisfactorily. The first rain produced another slide, the logs carrying the material over the arch. With the drain in the rock at a distance of 12 ft. from the edge of the cut and over 30 ft. from the foot of the new slope, a good foothold had been created which served the purpose, for no further movement of the overhanging masses (estimated by the engineer in charge as reaching the enormous quantity of 130,000 cubic yards) has taken place since that time (1904). The few sticks of timber in the arch which had moved, were displaced not more than an inch.

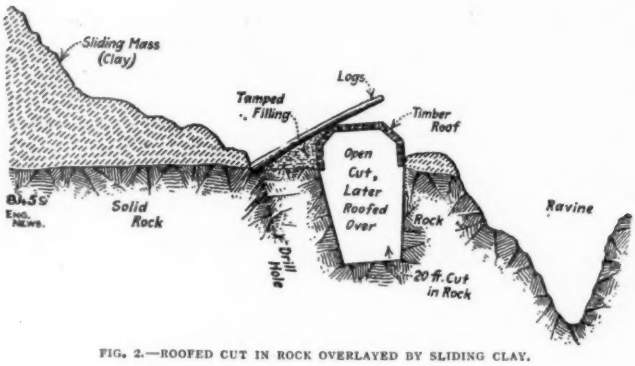


FIG. 2.—ROOFED CUT IN ROCK OVERLAYED BY SLIDING CLAY.

This experience led the writer to the conclusion that many similar slides formed by masses moving along a rock surface might be checked by boring holes down to rock, lowering dynamite and breaking the surface by means of blasts, and actual practice has confirmed this view.

Permissible Length of Flat Spots on Railway Wheels.

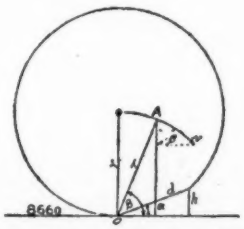
A formula for the energy with which a flat wheel strikes a rail has been developed by E. L. Hancock, of the Perdue University. The steps by which it is arrived at are thus given by the *American Engineer and Railroad Engineer.*

Let the diagram represent the wheel, of radius r, having a flat of length d. Represent the velocity of the train by v. At any instant it may be considered that the kinetic energy of the wheel, with its weight, considered as rotating about the point O, is the same as if the mass supported by the wheel be regarded as concentrated at its centre, that is, its kinetic energy is $\frac{1}{2}Mv^2$, where M is the combined mass of the car and wheel and v is the velocity of the train. When the flat spot is in contact with the track the centre of the wheel is at the point A, distant below the original position approximately $\frac{1}{4}h$, which is equal to $d^2 \div 4D$, where d is the length of the flat spot and D is the diameter of the wheel. At the point A the mass has a downward velocity equal to $v \cos \beta$.

But $\cos \beta$ equals $d \div D$, so that the kinetic energy with which M strikes the rail is $\frac{1}{2} Mv^2 \cos^2 \beta = \frac{Mv^2 d^2}{2 D^2}$, where v is the velocity of train in feet per second, d the length of flat spot in feet and D the diameter of the wheel in feet.

It is assumed that the permissible kinetic energy of the blow caused by the flat spot should not exceed the kinetic energy with which the weight strikes a rail in the prescribed drop test. Hence the energy of the impact as deduced is equated to 380,000 foot-pounds, the energy of a 2,000-pound weight falling through 19 feet.

The weight upon a car wheel being assumed to be 10,000 pounds and the diameter of the wheel 33 inches, the formula becomes $d = \frac{29{\cdot}4}{v}$ . . . . (A).



PERMISSIBLE LENGTH OF FLATS ON RAILWAY WHEELS.

While the energy of impact will be slightly increased by reason of the action of gravity increasing the velocity of the mass during the fall through the distance of A below the centre, approximately $\frac{h}{4}$, it is found that this is so small as not appreciably to affect the results.

A formula corresponding to (A) for a 6-ft. driving wheel, assuming a load of 25,000 lbs. on the driver, is: $d = \frac{40{\cdot}6}{v}$ . . (B)

The following table shows the values of d for various speeds:

LENGTH OF FLAT SPOT PERMISSIBLE.

33-inch wheel—Formula A. 72 in. wheel—Formula B.

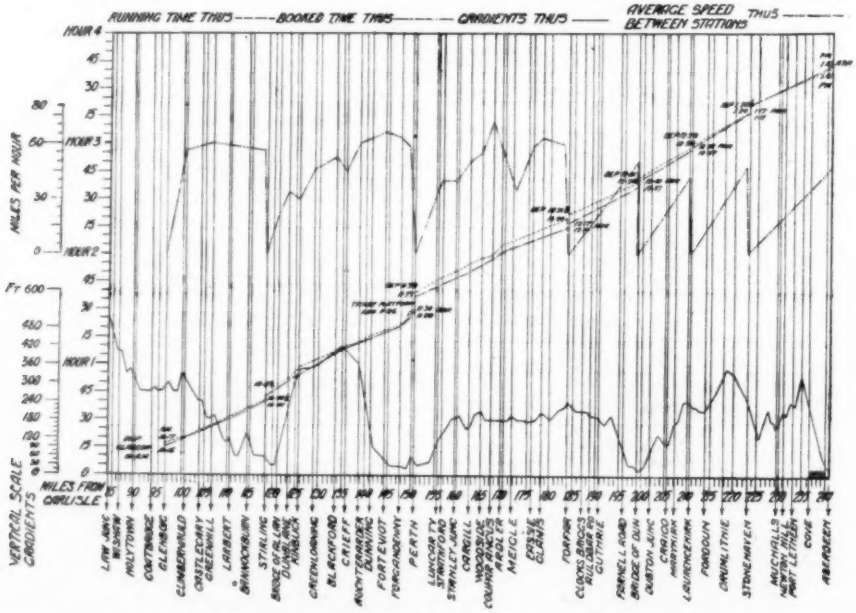
Speed v, in m. p. h.—	d in ft.	Factor of safety of 10, d in in.	d in ft.	Factor of safety of 10, d in in.
10	2·90	3·48	4·06	4·87
20	1·42	1·68	2·03	2·43
30	0·96	1·15	1·35	1·62
40	0·73	0·87	1·01	1·21
50	0·59	0·70	0·81	0·97
60	0·49	0·58	0·67	0·80
70	0·42	0·50	0·58	0·69
80	0·36	0·43	0·50	0·60
90	0·32	0·38	0·45	0·54
100	0·29	0·34	0·41	0·49

Everyday Performances of Leading British Locomotives.

III.—THE CALEDONIAN.

Excellent work is performed on the Glasgow, Perth and Aberdeen length of the Caledonian Railway by the 908 class of the 4-6-0 type, although the winter timings are not so fast as those during the summer, when booked speeds on the Perth-Forfar stretch have been as high as 59 m.p.h. on the down and 60·9 on the up journeys.

On the run made in January last by the writer, the booked speed of the 10 a.m. ex Buchanan St. between the places mentioned —32 miles 40 chains, in 37 min.—was only 53 m.p.h., the whole run to Aberdeen, 153 miles, in 3 hrs. 42 min., working out at 45·4 m.p.h. with stops at Stirling, Perth, Forfar, Bridge of Dun, Laurencekirk and Stonehaven. With such timings the full capabilities of the engines are scarcely called into requisition; and on the run in question, although some time was lost on the first part of the journey, the train ran into Aberdeen ahead of time. Some smart running, however, was made, the speed, as



RUNNING OF THE 10 A.M. TRAIN, GLASGOW (BUCHANAN ST.) TO ABERDEEN. ENGINE NO. 908 TO PERTH, NO. 905 TO ABERDEEN, 4-6-0 TYPE.

will be seen from the accompanying chart of the run, rising to 70 m.p.h. between Woodside and Ardler. Engine 908 itself took the train of 10 vehicles, = 56 axles, to Perth with a slip at Crieff; Larbert (22¼) was passed in 29 min. 30 sec., and Stirling (30¾) reached in 40 min. 10 sec. From Stirling to Perth ticket platform (33⅜) the net time was 42 min. 30 sec. No. 905 ran from Perth to Aberdeen with 7 vehicles including a dining car, = 35 axles, a carriage—Edinburgh to Blairgowrie—being slipped at Coupar Angus. Known as the Grampian Corridor Express this train is deservedly popular, being made up of well-appointed and very comfortable vestibuled corridor stock including a dining car.

Iron, Steel and the Foundry.

Conducted by PERCY LONGMUIR.

IRON AND STEEL INSTITUTE, SPRING MEETING.

Cast Iron in the Construction of Chemical Plant.—In this communication Mr. F. J. R. Carulla speaks highly of the value of cast iron to the chemical industries and examples, such as ammonia stills, are quoted to show the resistance offered. None of the special mixtures so familiar to this branch of foundry practice are touched on, hence the paper is of general rather than foundry interest. Incidentally, a suggestion is given in regard to hydrochloric acid, the action of which is extremely rapid on cast iron. As grey iron is more rapidly attacked than white the latter is preferable but is also more brittle. In order to minimise brittleness and to obtain the greater resistance of white iron, the author suggests chilling the inside or working portions of the pans.

The Utilisation of Blast Furnace Slag.—The Chevalier C. de Schwarz calculates last year's production of blast furnace slag at about 50,000,000 tons, and assuming that a ton of ungranulated slag measures, when broken up, about 20 cubic feet, the slag product of one year will then be represented by a mountain of nearly 1,000,000,000 cubic feet. Hence the disposal of slag is a problem of some importance. Of the means at hand the two chiefly considered are as slag brick and Portland cement. The advantages of slag bricks over ordinary baked clay bricks are:—

(a) They offer higher resistance to crushing.

(b) Houses built with slag brick are never damp and can be occupied without danger to health as soon as they are built.

(c) Slag bricks are more accurate in shape and dimensions because they are not baked and therefore do not shrink like clay bricks.

After considering the production of brick and cement, the author notes, in conclusion, "That Portland cement made from blast furnace slag has been employed for buildings, bridges, fortifications, railway embankments, &c., as well as for buildings in sea water, for the last fifteen years, without showing the slightest injury after so long a period is proof enough that any prejudices against its use are thoroughly unfounded." (*See* pp. 380—387.)

The Metallurgical and Chemical Laboratories in the National Physical Laboratory.—Mr. Walter Rosenhain describes at considerable length the equipment of these laboratories and the methods followed for the analysis of iron and steel.

FIG. 1.

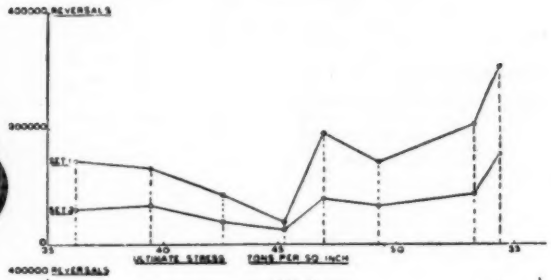


FIG. 2.

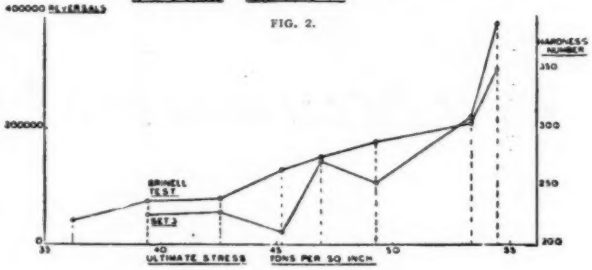


FIG. 3

Neither equipment nor methods call for special comment, the methods described being familiar to the average steel works laboratory.

A New Fatigue Test for Iron and Steel.—Dr. Stanton describes a test for iron and steel in which the specimens are submitted to a combination of rolling abrasion and alternate bending. The principle of the test is shown in Fig. 1 where *R* is a hollow ring of rectangular section cut from the steel to be tested and placed between three hardened steel rollers symmetrically placed as shown. If the upper roller is loaded with a weight, *W*, the ring will be in equilibrium under three equal forces, *W*, at the lines of contact, and by rotating the upper roller motion will be communicated to the lower ones by the rolling friction of the ring. Thus the outer surface of the ring will be subject to rolling abrasion, and every radial section of the ring will be subject to alternate bending stresses which will go through a complete cycle three times in one revolution and the magnitude of which can be calculated from the dimensions and the load. A simple machine built on these lines worked satisfactorily, with the exception that the load on the upper roller could not be made considerable owing to the resistance of the bearings of the lower rollers, which soon became greater than the frictional resistance at the line of contact with the specimen. A new machine was therefore designed and constructed as shown in Fig. 4. In this the axles of the lower rollers are supported on the rims of friction wheels, an arrangement which results in the specimen rotating uniformly up to the highest loads used until fracture. The rollers and their axles are made of tool-steel, hardened and ground to the same diameter. The upper roller revolves in a double brass bearing hinged to the side plates of the machine, and motion is communicated to it from a shaft parallel to its axis through an "Oldham" coupling which allows the roller to sink without constraint as the specimen wears. The load is applied by a weighted lever, whose knife-edge rests on a saddle supported from the bearings of the upper roller by the side rods shown in Fig. 4. The behaviour of a specimen under test consists of a wearing down and spreading over the edges of the outer surface to an extent depending upon the hardness of the material. After some thousands of rotations the surface begins to slightly disintegrate and falls off in thin flakes. As the test progresses small cracks running parallel to the axis begin to appear on the inner and outer surfaces, or both. These develop until fracture occurs, and a

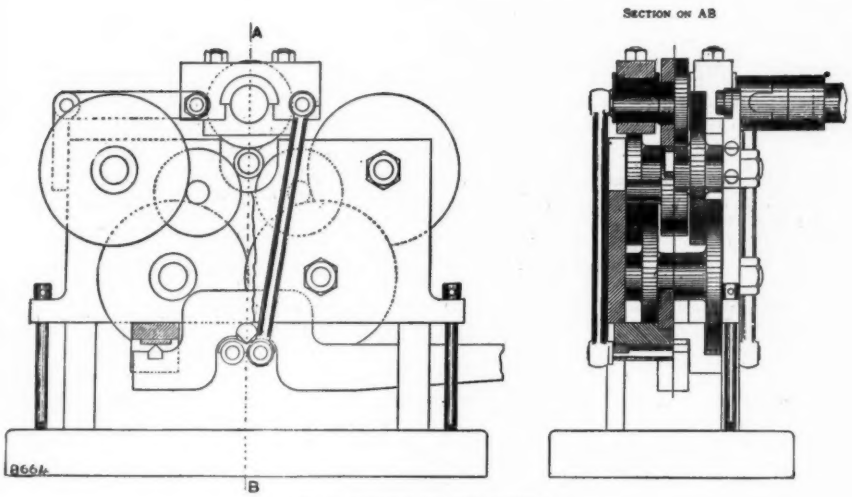


FIG. 4.—FATIGUE TESTING MACHINE.

characteristic fracture is shown in Fig. 5. Some of the results obtained are plotted on a base of ultimate stress in Figs. 2 and 3, and in Fig. 3 the calculated hardness numbers from the "Brinell" test have been plotted.

The Pyrometric Installation in the Gun Section, Royal Gun and Carriage Factories, Woolwich.—Mr. W. Lambert describes the method of temperature measurement followed in the treatment of ordnance. Practically only one type of pyrometer is employed, consisting of thermo couple, Holden d'Arsonval dead beat galvanometer, and scale for reading temperatures. The recording instruments are the well-known "Pitkin" type constructed to the specification of Roberts Austen. The system has been so elaborated that practically all the furnaces are under pyrometric control.

The Application of Colour Photography to Metallography.—Mr. E. F. Law describes the application of the "Lumière" autochrome plates by which a photograph in colour is obtained on one plate by a single exposure. The process is a modification of the three colour method. The plates are exposed through the glass side and in front of the plate is placed a film of transparent starch grains of uniform size, coloured respectively red, green and blue, and mixed in the proper proportion to produce white. The light reaching the photographic film has to pass through this screen and is resolved into its components, with the result that on development a black image is produced behind every starch grain which has transmitted light. The after treatment of the plate is the reverse of the ordinary process. The photographic image is dissolved out by acid permanganate solution, and the unaltered silver salts are blackened by exposure to light followed by development. The result, therefore, is not a negative but a positive on glass, showing all the colours of the original by transmitted light.

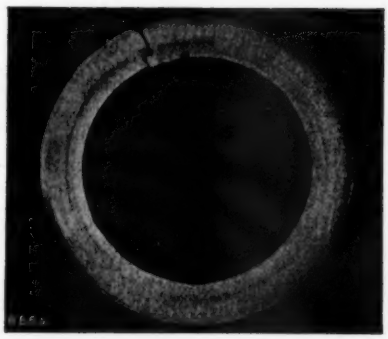


FIG. 5.—PHOTOGRAPH OF RING AFTER FRACTURE.

THE CARNEGIE RESEARCHES.

The Microscopic Features of Hardened Supersaturated Steels.—Mr. E. Hess reports the results obtained from an examination of three steels containing 1·01, 1·41 and 1·47 per cent. carbon respectively. Bars of each steel, 9 in. long by ¾ in. square, were heated in a muffle in such a manner that one end attained a full white heat, whilst 5 in. from the end the temperature was just within the critical range. The bars were quenched in iced brine, each bar therefore presenting a wide range of temperature variation, and sections taken along the length of the bar offer a means of examining the effect of this variation. From this examination the first conclusion reached is that the real condition of the steel at high temperatures is not necessarily preserved by sudden cooling. In the author's opinion, Howe's theory, that the supersaturated steels at temperatures above the critical range consist of austenite, is correct. Austenite is stable above the critical range, but in slow cooling through the critical range it tends to split into ferrite and cementite. The rate of cooling governs the extent to which this reaction is completed. In quenching steel from high temperatures the edge of the bar must have a quicker rate of cooling than the centre, and consequently while the edge will show approximately the condition of the steel at the quenching temperature, the centre should contain evidence of the decomposition of austenite into ferrite and cementite.

Researches of the Cooling Power of Liquids, on Quenching Velocities and on the Constituents Austenite and Troostite.—Dr. Benedick's title indicates a large field which, so far as may be judged from the published abstract, has been well covered. In the first place the author examines the effect of different liquids in cooling a heated metallic body. From this the conclusion reached is that the factor which plays the main rôle is the latent heat of vapour of the liquid. The specific heat is only of secondary influence, the heat conductivity may be neglected and probably also the internal friction of the liquid. It would therefore appear that the essential conditions for a quenching liquid to give effective cooling are:—(1) a high latent heat of vapour; and (2) so low a temperature that the vapour bubbles formed at the surface of the metal may be easily condensed in the surrounding liquid. The rate of flow of the liquid has very little influence on the effectivity of the cooling.

In dealing with troostite the author shows that its occurrence depends on the cooling velocity and not on the quenching temperature in itself. As in the case of pearlite the formation of troostite is accompanied by recalescence. The electrical resistivity of troostite is similar to that of pearlite, and the specific volumes are also identical. These results are in accordance with the author's earlier theory, that troostite is a solid, colloid solution of cementite in iron, or in other words a pearlite having ultra-microscopic particles of cementite.

In regard to austenite, the most important fact found is that the preservation of austenite requires a high mechanical pressure. Austenite never occurs in the outer layer of a hardened specimen, but it is erroneous to ascribe this to oxidation, for it has been shown to depend on the lack of the necessary pressure. If the mechanical pressure in an austenite martensite specimen is decreased by grinding off an essential portion, then some of the austenite thus exposed is in a short time transformed into martensite. On the other hand, if the mechanical pressure on the surface of a cylinder is increased during cooling, the anstenite will be richly preserved even at the extreme outer edge.

Hardness of the Constituents of Iron and Steel.—Perhaps the one point of interest in Mr. H. C. Boynton's report is to be found in the reasons advanced for the increase in hardness due to excessive wire drawing. The hardening effect may, in the author's words, be due to one or other of the following:—

1. The intermingling of some of the harder constituents with the softer owing to the intense mechanical distortion; or
2. To an allotropic change in the iron; or
3. To a chemical change in the carbon; or
4. To a combination of an allotropic change and a chemical change; that is to say, possibly the hardening carbon present in the sorbite helps to hold the iron in an allotropic form, which form has been converted into this state by the deformation.

Function of Chromium and Tungsten in High Speed Steel.—Mr. C. A. Edwards reports the result of an examination of a series of high speed steels of, on the one hand, varying chromium content, and on the other, varying tungsten content. Cooling curves of the steels containing more than 3·0 per cent. chromium and 6·0 per cent. tungsten, taken from 1,200° C show

a critical range, beginning at about 380° C ; whilst the same steels cooled from 1,320° C show no critical ranges below 900° C. Many workers hold the opinion that the change from hardening to pearlite carbon is retarded by the mere presence of such elements as chromium, tungsten, or molybdenum when the steels are cooled from between 1,200° and 1,300° C. Osmond says this change is lowered in proportion as the quantity is raised above the eutectoid composition. Swinden has shown that the maximum lowering effect of 3·0 per cent. tungsten is about 130° C, so that if Osmond's theory is correct, the charge point of an alloy containing 19·0 per cent. tungsten would be lowered to – 133° C. That such is not the case is shown by the fact that all the steels show the so-called lowered Ar1 point at about the same temperature, namely, 380° C. The author's opinion is that the low point is not Ar1 lowered by tungsten, but that a carbide of tungsten is slowly formed at about 1,200° C, which has a critical temperature quite independent of Ar1. As there are no critical points below 900° C with alloys cooled from 1,320° C, there can be neither carbide of iron nor the hypothetical carbide of tungsten present, but rather would it seem that the carbide of tungsten first formed at about 1,200° C combines with the chromium at higher temperatures to form the double carbide. This double carbide is held in solution on cooling, but on heating is deposited at 670° to 730° C, is slowly decomposed at higher temperatures into carbide of tungsten, and on soaking iron carbide is again formed. The function of chromium as deduced from the author's work is to impart to the alloys, when cooled from high temperatures, a high degree of hardness, and to increase the resistance to tempering. This result is only possible when the requisite amount of tungsten or molybdenum is present.

Steel and Iron Refining by Means of Vapours of Metallic Sodium.—Mr. A. Hiorth reports a series of preliminary trials on the purification of iron by means of sodium, this metal having an affinity for the most impurities, viz., oxygen, sulphur, and phosphorus, without forming an alloy with the iron. From the author's report we gather that much further investigation is required, but for the present the conclusions reached are:—

1. Iron treated with small quantities of sodium vapour is more fusible, and will remain molten longer than other iron.
2. That such treatment will remove the oxygen.
3. That by treating iron or ore containing oxygen with sodium vapour, a valuable product, sodium peroxide is obtained.

Iron, Carbon, and Sulphur.—Mr. D. M. Levy reports an examination as to the effects of sulphur on the relations of carbon and iron. From the work done the author concludes that the iron carbon alloys are essentially an iron carbide series, and that the graphitic system does not separate directly as such, but results from the decomposition of separated carbide. Carbon in iron passes into solution only as carbide, and separates out as such. In cast irons free from silicon and manganese, sulphur up to 0·8 per cent. exists as Fe S with a melting point upwards of 1,180° C. Sulphur lowers the melting point of cast iron, *i.e.*, the temperature of separation of the first constituent to solidify, which separates free from sulphur. The sulphur concentrates in the mother liquor, and separates at a temperature of 1,130° C as a component of the austenite cementite eutectic, forming a triple austenite cementite-sulphide eutectic. The temperature of this separation is slightly lowered as the sulphide increases towards 0·8 per cent. With prolonged cooling the components of the eutectic areas tend to ball up and run together; in sulphur free irons this secondary segregation proceeds with great rapidity, at temperatures about 1,130° C ; the massive cementite thus produced is decomposed rapidly at these temperatures, and grey irons result. The presence of iron sulphide in the eutectic introduces intervening layers which may partly ball up, but even then leave sulphide films between the cementite crystals; these act as emulsifiers, preventing the coalescence which is a preliminary to the decomposition of the carbide, and the iron tends to remain white. The author finds no evidence in support of the view that chemical union between iron, carbon and sulphur is the cause of sulphur tending to retain carbon in the combined form in irons, but considers that the purely physical, or rather mechanical, effects of the sulphide offer a satisfactory explanation of its action, exercised even by very small proportions.

Erratum. In describing the Eddy-current testing brake in our March issue we mentioned that Messrs. Frampton & Paine were the patentees and manufacturers instead of Messrs. Morris & Lister, Carlton Works, Coventry. Messrs. Frampton & Paine act simply as the sole selling agents.

ELECTRICAL PROGRESS

By ANDREW STEWART, A.M.I.E.E.

Reversing Rolls Operated Electrically.

An interesting paper dealing with this subject was read a short time ago to the Cleveland Institute of Engineers by Mr. Henry Crowe. The author confined his observations to reversing mills, as these provided quite enough matter for one paper.

The greatest disadvantage of the electrically operated rolling mill was its high capital cost, and it is doubtful if, in some cases, any economy in fuel commensurate with the capital involved, is possible. For this reason, if for no other, rolling mill owners have little inducement to spend money on a generating plant, with the addition of flywheel converters &c., to drive their mills. If however, electric supply can be purchased outside, the capital cost of a generating plant is eliminated, and although the interest charges must be paid by the user, these are smaller than would be the case if the user had his own plant, by reason of the much larger scale on which the electric supply undertaking is carried on, while spare plant &c., will serve a much larger number of users.

It is probable that this factor has led to the more extensive adoption of electric driving in Germany, where fuel is somewhat dearer, and there are many large stations where electricity is generated by gas engines using blast furnace gases; thus electric supply may even be cheaper than in this country, in spite of the higher cost of fuel.

In any case, whatever the cause, it is clear that the electrically driven rolling mill has become more popular in Germany than here, and, while it does not follow that what is satisfactory in Germany is equally so here, it may be just as well to reproduce some of the author's data and figures.

The Ilgner system, now usually employed to flatten out the load of the mill, has been very exhaustively treated at one time and another in this column. It is sufficient to point out, therefore, that the converter proper consists of a three-phase induction motor, where the supply is three-phase, a heavy flywheel, and a direct-current generator, the latter supplying current to the rolling mill motor. As the mill load comes on to the direct-current generator, it tends to slow up, but this tendency is checked by the heavy flywheel which tends to keep the set running with only a very gradual reduction in speed, the kinetic energy of the flywheel meanwhile reappearing as electrical energy at the generator terminals. As the operation of reversing is only a matter of seconds, the value of the flywheel will be appreciated.

Large mills require ten to fifteen thousand h.p. momentarily, and without some such system of levelling out the load on the supply side, and flywheel storage, the supply of these mills from public supply systems would be impossible.

A further gain is to make the actual coming to rest of the mill motors, produce electrical energy to help to accelerate the flywheel. This is done by arranging the control lever so that when brought to the position to bring the rolls to rest, the fields of the motors are so strengthened that momentarily they give an E.M.F. in excess of that of the direct-current generator, and a large current flows back to the generator tending to cause it to accelerate the flywheel. At the same moment this rush of current brakes the motor driving the mill. By this means the control of the mill is even more exact than when steam driven, and the regenerative action is a source of considerable economy.

The even torque of the electric drive reduces the breakages of boxes and shafts, and wobblers of rolls. The mill is less likely to stall, and will pull anything through up to the maximum load that the circuit breakers are set for.

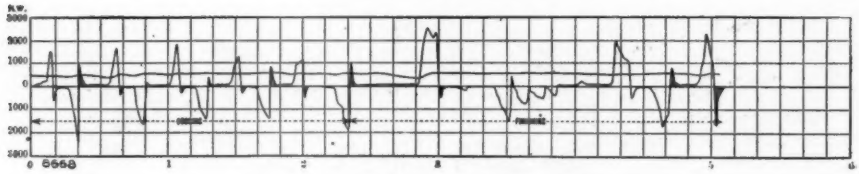


FIG. 1.

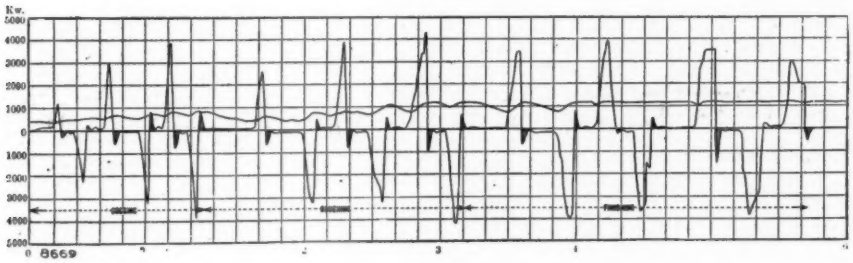


FIG 2.

Fig. 1 shows the fluctuations in power, and the power taken from the supply by the converter, when the mill is rolling a 1·45 ton ingot into 4 ft. × 4 ft. blooms. It will be clear from the saw tooth nature of the curves that the fluctuations of the load on the mill motor are extremely violent, while the almost perfectly level line at 500 kw., showing the current taken by the converter from the source of supply, indicates how very successful the converter is in smoothing out the irregularities in the mill load. The shaded portions represent the regenerative portion already mentioned.

The elongation of this particular ingot was 14·6 times the original and the average power supplied to the rolls was 338 kw. for 310 secs., = 29 units, while the energy supplied to the converter 488 kw. for the same period or 42 units, giving an overall efficiency of 69 per cent., and 29 units per ton.

Fig. 2 shows another diagram from a mill rolling 17 in. × 18 in. ingots into joists 11 ft. × 6 in. There were 19 passes and the power rises to as much as 4,400 kw., equal to almost 6,000 h.p. during the roughing process. Here again the power taken from the source of supply seldom exceeds 1,000 kw., and is sometimes little more than half this. The overall efficiency in this case is 73·5 per cent., and the units per ton = 52.

It appears, from results obtained in various electrically operated mills, that the following represents current practice so far as these can be ascertained.

TABLE I.

Results obtained in electrically operated Rolling Mills.

1·35 ton ingots into	2 ft. × 2 ft. billets,			52	units per ton are required.	
1·45 ,, ,, ,,	4 ft. × 4 ft.	,,	,,	29	,,	,,
1·8 ,, ,, ,,	41 lb. joists			56	,,	,,
1·85 ,, ,, ,,	86 ,, ,,			53	,,	,,
1·5 ,, ,, ,,	72 lb. rails			60	,,	,,
1·4 ,, ,, ,,	53 ,, ,,			70	,,	,,

The rolling must be carried out quickly if economical results are to be obtained. As an instance of the importance of this, the second result viz. 29 units per ton was obtained when the mill was turning out 17 tons per hour. When the output was reduced to 14 tons per hour, the units per ton rose to 33. With an output of the order of 50 to 60 tons per hour which, by the way, is more nearly representative of modern working conditions, the units per ton fall to 22.

This is due largely to the fact that the converter set is running all the time, and it uses about 120 to 130 units per hour even if the load passing through the mill is nil. The figures given are all from German practice.

A New Underground Conduit Electric Tramway System.

So long as we have inventors we shall find that a fair proportion devote their attention to challenging the position at present held by the overhead trolly system.

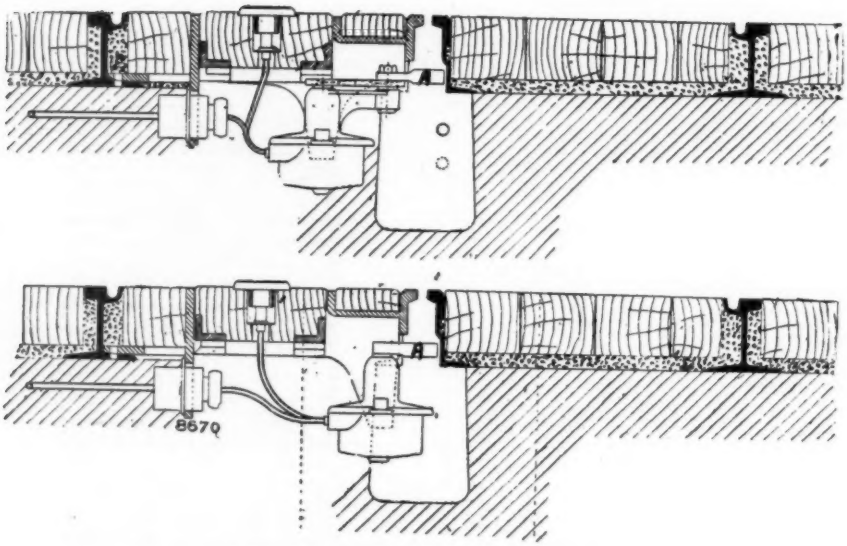


FIG. 3.—THE "ROBROW" SURFACE CONTACT SYSTEM.
The upper illustration shows the system applied to a line already using cable haulage. The switch lever A being the only additional gear in the conduit. The lower illustration shows a shallow conduit specially built for the system.

The latest underground conduit system seems quite as good as any of its rivals, and better than some. Moreover it renders possible the easy conversion of cable tramways to electric haulage, and for this reason may be welcomed by corporations such as Edinburgh, who have been benighted enough to adopt cable haulage when every other cable haulage plant was being put on the scrap heap.

Fig. 3 shows the cross section of the track and conduit, indicating also the position of the stud and switch box.

A feeder is laid alongside the track and tapped off to each box as shown. The current passes through the cable to the switch box, and then to the stud, when the switch is closed. This is effected by means of the arm A, which is pushed over by the plough which consists merely of a steel projecting bar, and serves no other purpose than to operate the switch.

When the switch is closed by the plough the current flows to the stud as already indicated, and from this stud it is collected by a skate in much the same manner as in the case of other surface contact systems. The stud is only alive during the period the car is over it. This is made possible by the fact that the switch returns to the "off" position immediately the plough releases it, this being effected by a spring.

The weakness of all surface contact systems is the possibility of the studs being left alive after the car has passed. This is fairly well guarded against by the provision made to return the switch to the "off" position, but in case this should fail, a safety earthing device shown in Fig. 4 is provided.

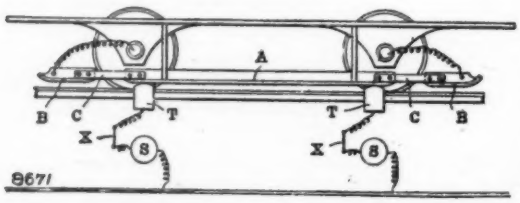


FIG. 4.—EARTHING DEVICE FOR THE CAR.

The electrical connections to the feeder are shown, and the switch at *S*, fuse *X*, and stud *T*, while the skate is shown at *A*. On each end of the skate is an earthing device *B* supported by

insulating bar *C*. This earthing device is connected to the car axle, and immediately it touches a live stud earths it, and the rush of current blows the fuse *X* thus leaving the stud dead—not even alive when the skate *A* touches it under normal conditions. The switch, which is, of course, out of repair when it allows the stud to remain alive is now inoperative, and the fuse must be replaced and the switch repaired before this stud again becomes available.

It seems that the inventors have by this means removed all reasonable probability of the studs remaining alive after the car has passed, and it remains to be seen how it will operate in practice. At present the system is being applied to the Benares Tramways, and we shall await the operating results with interest.

Developments in Electrically-Propelled Road Vehicles.

Two months ago we foreshadowed developments in connection with the Edison battery for automobile work.

Much that is impossible has been written about the Edison battery, but beneath the froth of journalistic enterprise which has attributed almost mystic powers to this new battery, there lies much that is substantial, and within the last few years a vast amount of work chiefly in perfecting the process of manufacture, has resulted in the production of a battery which, while not very extraordinary, when judged by what the daily press has led us to expect, nevertheless represents a substantial contribution to the progress of the electrically-propelled road vehicle.

As our readers are aware, the basic objection, indeed the only consideration, which has hitherto militated against the success of an electrically-propelled road vehicle, has been the depreciation of the storage battery. A lead storage battery is a short-lived appliance when worked hard; it has still shorter life when carried about on a vehicle where, despite pneumatic tyres and springs, it must be subject to vibration. Roughly speaking the battery has to be figured at a depreciation of 20 to 25 per cent. per annum, and it is a good battery indeed that comes out at the lowest of these figures.

We have recently made some extended trips in vehicles propelled by the Edison battery, with a view to ascertaining the

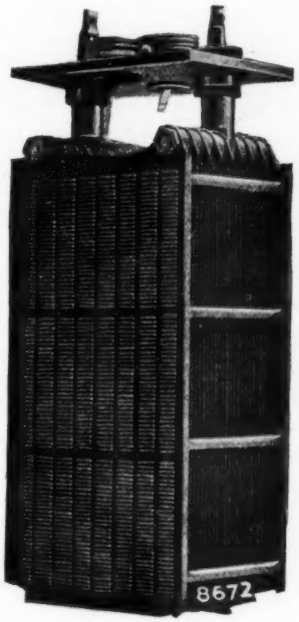


FIG. 5.—GROUP OF PLATES OF EDISON BATTERY.

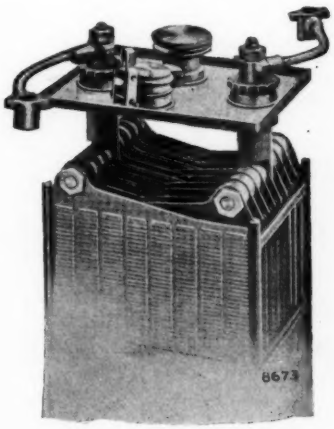


FIG. 6.—TYPE OF CELL SHOWING GROUPING OF PLATES, TERMINALS, GAS CHECK VALVE, AND FILLING UP OPENING.

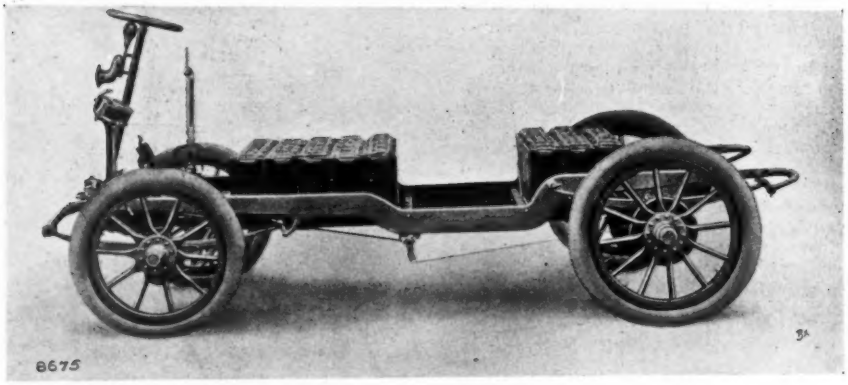


FIG. 7.—CHASSIS FOR LANDAULET, WITH BATTERY ARRANGED UNDER THE SEATS.

staying power, and overload capacity of the cell. The results seem to indicate that it may be subjected to treatment which would almost ruin a lead battery, and yet show no signs of deterioration. The cell may be, and has been, overloaded momentarily to the extent of 350 per cent., it has been discharged down to zero, and charged in less than three hours with no apparent injury, indeed robustness is a characteristic feature of this battery.

Fig. 5 shows a group of plates which consist of a nickel steel frame containing spaces which are punched out to hold rows of pockets. These pockets are of nickel with numerous small holes to allow the electrolyte which, by the way, is not sulphuric acid, as in a lead battery, but merely a solution of caustic potash. Apart from the comparatively harmless nature of the electrolyte, it gives off no obnoxious fumes during charge or discharge, and in this respect alone scores heavily over its lead rival.

The rows of nickel pockets seen in the illustration are filled with iron or nickel oxide, ground to a fine powder, the use of iron or nickel determines whether the plate is a positive or a negative one.

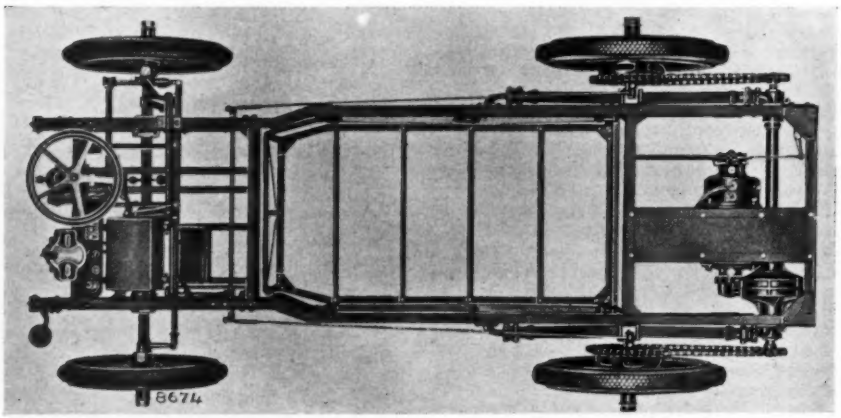


FIG 8.—CHASSIS FOR 2-TON DELIVERY WAGGON.

The top of the cell (Fig. 6) forms the lid of the containing jar, also a metal box, this top has the two terminals, a small inlet for filling in the solution and adding the small amount of distilled water, which is added about every three or four weeks to make up for evaporation, beyond this the cells need no care, quite unlike the nursing which a "sick" lead cell gets when it shows signs of deterioration. In addition, there is a small gas check plug which permits the exit of any gases which may tend to accumulate inside the cell.

As the voltage of a nickel iron combination is much below that of a lead cell, being only 1·23 volts per cell, it is necessary to use a larger number of cells to get the same voltage, or, as is more usual, to use a motor wound for a lower voltage.

Generally, 64 cells giving 80 volts are used, and the illustration (Fig. 5) shows the plates of a 175 ampere-hour cell. The capacity of the battery is about 11 watt-hours per lb. or roughly speaking 1·66 horse-power hours per cwt. The battery on a car usually has a capacity of about 14 kw. hours = 19 h.p. hours, and can cover fifty-six miles on a reasonably level road with one charge at a maximum speed of sixteen miles per hour.

Fig. 7 shows a carriage chassis fitted with the Edison battery and Fig. 8 a chassis for a two-ton delivery waggon, where, of course, space for the cells must be found below the top side of the frame. Most of the vehicles now in use in Europe having Edison batteries have been built by the Bergmann Electricitäts Gesellschaft of Berlin, who own the European rights for the Edison battery, though the business in Great Britain is handled by Messrs. Marples, Leach & Co., Ltd., who are sole agents. The cars made by Messrs. Bergmann have almost invariably single motors driving to the rear axle by spur gear, or chain, the latter in the case of slow-speed commercial vehicles. Vehicles fitted with hub motors are of course made, these, while they give easier running, are slightly less efficient.

A standard landaulet chassis has a single series wound, 5 h.p. motor, which, however, is capable of giving 15 h.p. for one hour, driving by spur gearing having a ratio of five to one, to the back axle where the differential is mounted. The axles have roller bearings. The energy comsumption on such a car is about 120 watt-hours per ton mile equal to about ·16 h.p. hour per ton mile, so that given electrical energy at the usual price for power, viz., 1*d.* per unit (1,000 watt-hours) the cost of energy for operation compares more than favourably with any automobile at present known.

SIXTH WORKSHOP PRACTICE PRIZE COMPETITION.

We again offer four prizes—one of £4 and three of £1—for the best short article describing and illustrating any emergency device or job that has taxed the ingenuity of those in charge of machine tools, or who are engaged in fitting or erecting.

Instructions and Conditions.

Articles must be written on one side of the paper only, and be signed by the competitor.

Drawings and sketches must be on separate sheets of paper.

A short biographical sketch of the competitor's technical experience must accompany the article.

The right is reserved of publishing the prize articles, and also any of the others sent in; but in the case of the latter, payment will be made for the same at our usual scale rates.

The Editor's decision in all matters connected with the competitions shall be final, and binding on all the competitors.

All articles should be addressed to the Editor of The Engineering Review, 104, High Holborn, London, W.C., and marked on the outside, "Competition," and the same must be received not later than June 15th.

GENERAL REVIEW

LEADING ARTICLES OF THE MONTH—CURRENT EVENTS—TECHNICAL INFORMATION FROM ALL SOURCES.

Dustbin Refuse as a Fertiliser.—A novel experiment has been carried out by Mr. A. Harrison, engineer of the Borough of Southwark, in connection with the disposal of refuse in that district, with such satisfactory results that an extension of the system has been decided upon. Briefly, the house refuse is brought in by the vans and shot down in front of, and then shovelled into, suitably designed crushers or manipulators, all large material, representing about 5 per cent., being thrown on one side and disposed of by other means. The material when crushed is of a light texture, not unlike mould in appearance, and it falls from the crushers on to a conveyor discharging direct into railway trucks. It is then sent to farmers, the sale price being 2*s.* 3*d.* per ton within 25 miles of the Council's siding, this price covering carriage, and leaving a small sum towards the cost of crushing. The crushed material has been found to be useful to farmers and others for use on stiff soils and grass land, the demand at the present time being far in excess of the quantity produced daily. The plant is driven by two 40 b.h.p. electric motors, and the cost of power, labour and working expenses for running the plant is about 1*s.* 6*d.* per ton, varying slightly according to the state of the weather and the nature of the refuse dealt with.

The plant is considered preferable to a dust destructor in this particular borough, as it occupies very little space, and crushes the refuse apparently without the slightest nuisance from dust or smell, and practically deals with the whole of the refuse, leaving a very small quantity to be dealt with by sale or burning, but as the conditions vary more or less in every district, the question as to which is the most suitable for any particular district is one that must be determined locally.

The manipulators, or crushers, were fixed in October, 1906, by way of experiment, and after alterations by the makers, have been running daily during the last eight months. The cost of the machines, motors, conveyors, buildings, &c., amounted to £2,190, and the crushers deal with about 40 tons daily, except Saturdays, working altogether 54 hours per week. With regard to the working expenses, these are no doubt considerably increased through the machines being too light, but even with this fault the result has not been unsatisfactory, the average cost per ton for crushing being as follows:—

	s.	*d.*	
Power	0	8	per ton.
Labour	1	1	,, ,,
Beaters, Grids and Repairs ...	0	3	,, ,,
Oil and Sundries	0	1	,, ,,
	2	1	,, ,,
Less Sale Price	0	7	,, ,,
	1	6	,, ,,

This figure is capable of being reduced, and with heavier machines the cost of beaters and grids, it is stated, will not exceed 1*d* or 1½*d.* per ton. We understand that the Works Committee has decided to advise the Council to extend the crushing plant so as to deal with the whole of the house refuse brought into their Manor Place Depot, the present plant being only capable of dealing with about half the quantity collected.

A New Design of Gear Teeth, to Minimise Waste of Power and Wear.—At a recent meeting of the Society of Engineers, Prof. Smith read an interesting paper on this subject of gear teeth. The paper opened with an acknowledgment of the now forgotten work of Edward Sang. It enumerated ten kinds of excellence in the teeth of wheels, only two of which influenced the orthodox cycloidal and involute designs. Besides uniformity of velocity, ratio and strength, the other points of consequence were obliquity of action, number of contacts, smallest practicable number of teeth, undercutting, sharpness of outline at shoulders, frictional waste of power, abrasive waste of material, change from correct shape by wear.

It explained advantages of short teeth, and denied that the thrust could be effectively divided between two contacts. It was, however, essential that contact should begin before

the previous contact finished. In the author's new design the contact lasts 1·12 times the pitch with two 12-teeth pinions gearing with each other, and 1⅛ times the pitch when two very large wheels are in gear, the addendum of the tooth being made ⅛ of the peripheral pitch.

The author then gave a simple formula for the frictional waste work of toothed gear, and calculated that of his new design in an average case to be in the ratio of 106 to 180 to that of ordinary involute teeth. The leading aim of the new design was to combine small obliquity of thrust with avoidance of sharp curvature in the outline. The touching face of the one tooth should have a radius of curvature only little less than that of the flank of the tooth geared with it; in other words, the "closeness of fit" between the two should be as great as possible. This prevented the squeezing of the unguent out from between the bearing parts, increased the effective width of bearing surface, and diminished the actual intensity of pressure.

The sharpness of outline at the shoulder increased with decrease of obliquity of action, and the actual design was a compromise between these opposing influences such as yields maximum efficiency, such as also secures a substantial increase of strength.

The paper contained six appendices, giving lengthy and detailed calculations of all the somewhat complicated elements and steps leading to the final equations formulating rules for wheel-tooth design, these final rules, however, being of easy application. It was also illustrated by several drawings and diagrams.

Speed Trials and Service Performance of the "Lusitania."*—Much has already appeared concerning the trials of the *Lusitania*, but the subject has not yet been exhausted, and, furthermore, the particulars of the service performance are interesting. In describing the machinery arrangement details are given of the forced lubrication system of which a diagrammatic sketch is given in Fig. 3. The following are the weights of the various revolving parts: High pressure turbine rotor, 86 tons; low pressure turbine rotor, 120 tons; astern turbine rotor, 62 tons. A large main drain or reservoir tank is placed amidships in such a position that the oil from all the bearings readily flows to it, the oil being pumped from this tank, through a system of filters, to gravitation tanks placed about 26 ft. above the bearings. These tanks are of sufficient capacity to maintain the oil supply to the bearings for 10 mins. after the stoppage of all the pumps. Gauges showing the pressure in the oil pump, discharges to the filters, and also the pressure in the main gravitation pipes, to the main bearing journals and thrusts, are fitted up at the starting platform as well as at the pumps. The drain from each bearing and thrust is led through a glass-sided receiver so as to make the flow visible, and a thermometer enables the temperature of the oil from each main bearing and thrust block to be taken and recorded. In the gravitation tanks are copper coils through which sea water is circulated, thus maintaining the oil at a temperature not exceeding 30° above that of the engine room.

With reference to the feed system, shown diagrammatically in Fig. 4, all the auxiliaries in the ship, excepting the turbo-generators and the evaporators, exhaust into a general system of auxiliary exhaust piping connected to the surface feed heaters, auxiliary condensers, and atmosphere. The turbo-generators exhaust into an entirely distinct system of piping connected to the contact feed heaters, auxiliary condensers, and atmosphere. The hotwell pumps draw from the hotwell and discharge

* Thomas Bell, Proc. Institute Naval Architects.

QUEENSTOWN TO SANDY HOOK—4 DAYS, 18 HOURS, 40 MINUTES.

Abstract of Engine-room Log for third Voyage West. Mean Draught, leaving Queenstown, 33 ft. 7 in. Mean Draught, arriving New York, 30 ft. 10 in.

Date—1907.	Steam Pressures.			Temperatures.		Vacuum.	Distance by Observation.	Mean Speed.	Mean Revs.	Coal consumed for Main and Auxiliary Engines.
	Boilers. lbs.	H.P. Recrs. lbs.	L.P. Recrs. lbs.	Hot-well.	Feed Water.					
Nov. 3	170	140·0	2·3	68°	200°	28"	21 knots.	24·24	182·5	40 tons.
,, 4	169·1	142·2	2·2	78°	197°	28"	606 ,,	24·28	182·6	1,090 ,,
,, 5	167·3	140·6	2·3	78°	198°	28·2"	616 ,,	24·6	182·8	1,090 ,,
,, 6	168·3	140·4	2·5	70°	196°	28·2"	618 ,,	24·8	183·5	1,090 ,,
,, 7†	168·3	138·3	2·2	72°	195°	28"	610 ,,	24·52	181·4	1,090 ,,
,, 8	165	132·5	1·5	75°	200°	27·8"	310 ,,	22·09	174	576 ,,
Means	168	139·3	2·2	74·5°	197°	28·1"	Total of 2,781 knots	24·25	181·1	4,976 ,,

SUMMARY OF TOTAL COAL CONSUMED ON VOYAGE:—Liverpool to Queenstown, 408 tons; Queenstown to New York, 4,976 tons; galleys, &c., 18 tons: Total coal taken from bunker from leaving landing stage, Liverpool, till moored at wharf, New York, 5,402 tons.

† Furious S.W. gale.

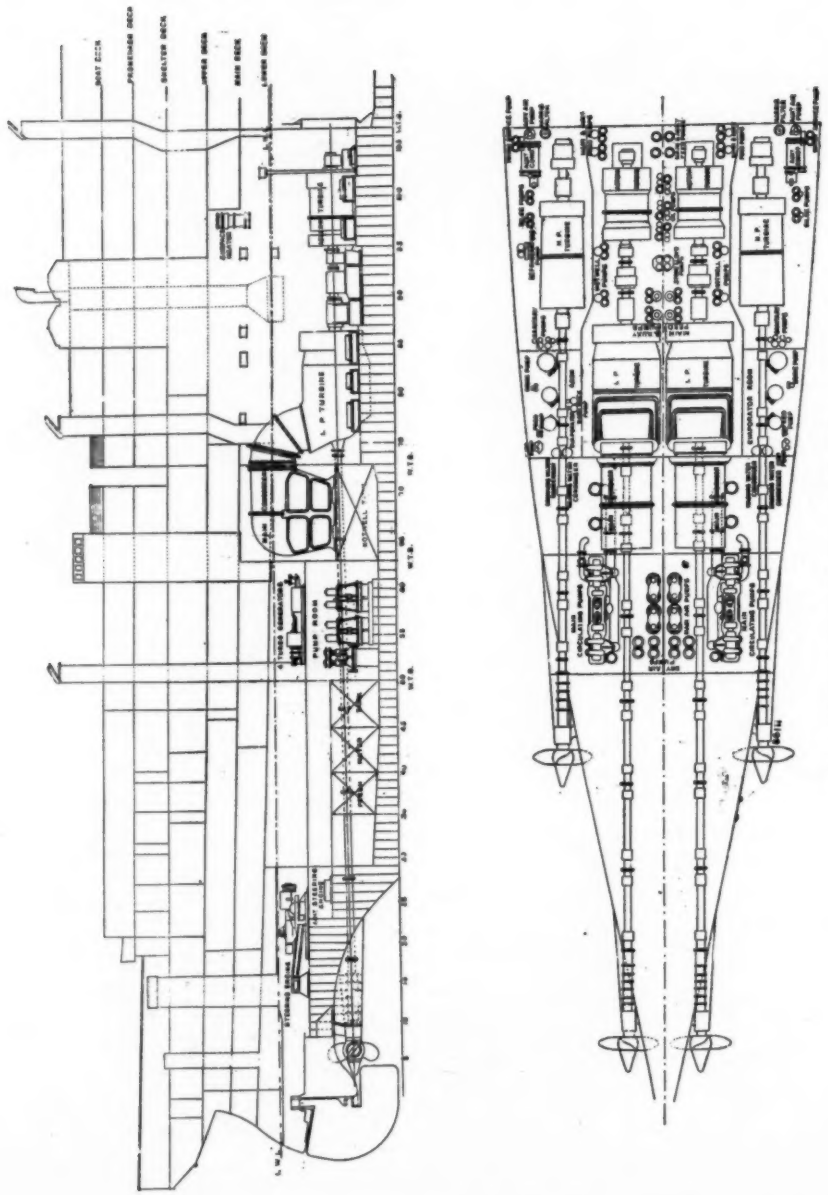


FIG. 1.—ARRANGEMENT OF TURBINES AND SHAFTING.

through two feed filters to the two surface feed heaters, and thence to the contact heaters; these latter constitute the usual feed receivers, and are fitted with float gear, controlling not only the steam supply to the main feed pumps, but also to the hotwell pumps. In addition, the hotwell pumps are controlled by float gear in the hotwell tanks—the latter, in case of a shortage of water supply, to prevent the pumps running away, and the former precluding the possibility of water being forced back to the turbo-generators, should the non-return valve in the steam inlet to the contact heater fail to act in the event of the feed pumps suddenly slowing.

In most large merchant ships, on account of accidents which have occurred, it has been the general practice to lead the exhaust from the electric engines direct to the main or auxiliary condensers only, to ensure steady running of the dynamos and to prevent the possible passing back of water from other auxiliary engines into the cylinders of the electric engines. In this present case the electric installation is so large, and the temperature of the hotwell, due to the high vacuum maintained, so low, that it was considered to be essential to utilise this exhaust for the heating of the feed water, and, by adopting this duplicate system of feed heaters and hotwell control, this end has been attained with a minimum of risk.

Particulars are given of the various trials of the ship and also those of the third voyage west from November 2nd to November 8th. The leading particulars of the official engine-room log for this voyage are given in the preceding table.

The steam consumption per shaft horse-power hour works out as follows :—

		Per shaft horse-power hour.
Main turbines	851,500 lbs.	= 13·1 lbs.
Auxiliary machinery	114,000 ,,	= 1·75 ,,
Evaporating plant and heating	32,500 ,,	= ·5 ,,
	998,000 lbs.	15·35 lbs.

Average amount of coal burnt per hour for all purposes = 43½ tons.

Water evaporated per lb. of coal = 10·2 from a feed temperature of 196°.
Water evaporated per lb. of coal = 10·9 from and at 212°.
Coal for all purposes per shaft horse-power per hour = 1·5 lbs.
Coal per square foot of grate per hour = 24·1 lbs.

Taking a mean displacement of 36,000 tons, this represents at 24½ knots a consumption of 11 lbs. of coal per 100 nautical miles per ton of displacement.

Brick Water-Cooling Tower.—A very substantial chimney cooling tower has been erected recently at the power station of the Central London Railway by Messrs. Balcke & Co., London, E.C., to the specification of Mr. H. F. Parshall, the consulting engineer, and Mr. E. P. Grove, the railway company's chief engineer. The illustration on page 413 represents the cooler. The tower is constructed entirely of brickwork. It rests on a solid concrete foundation, which had to be made of considerable depth and strength on account of the ground. The lower rectangular portion of the cooler covers a space of 30 ft. by 79 ft., with a height of 40 ft., above which rises the chimney with an additional height of 75 ft., and internal diameter of 24 ft., giving the whole structure a total height of 115 ft. above the ground. The rectangular portion is covered in

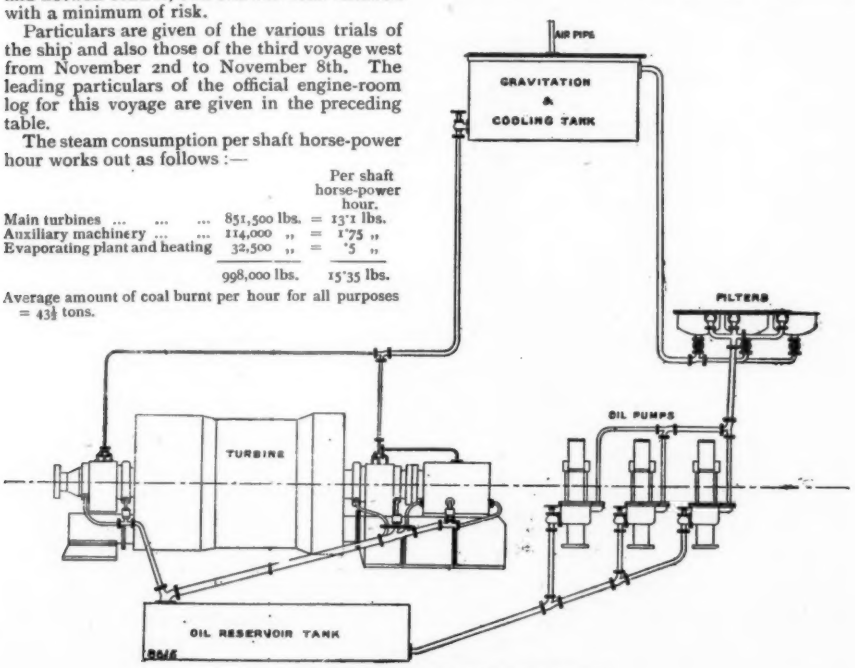


FIG. 3.—DIAGRAM OF FORCED LUBRICATION SYSTEM.

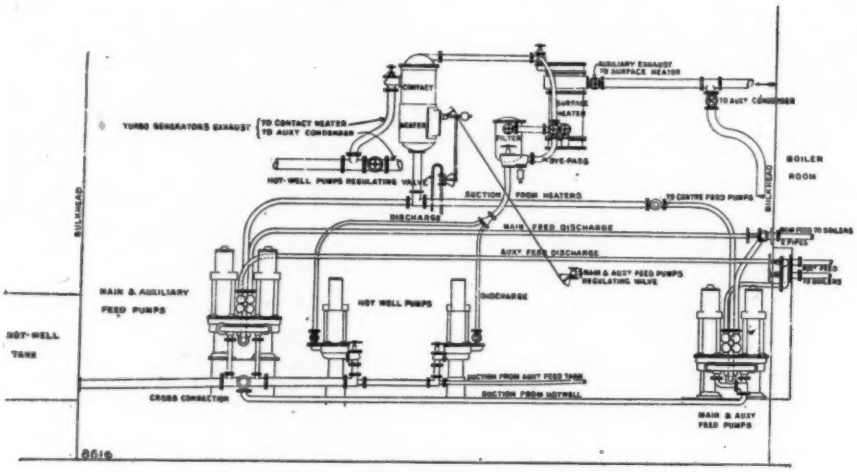


FIG. 4.—DIAGRAM OF FEED HEATING AND SUPPLY SYSTEM.

with a ferro-concrete roof. Air openings are left at the bottom of the rectangular structure. The foundation and brickwork of the chimney has been executed by Messrs. John Jarvis & Co., Builders, London.

The cooler is mainly for the condensing water of the new engines just installed, but the pipework is arranged at the same time so that the circulating water of any of the existing engines can be taken. The water enters the tower at two points on one side, the pipes being connected to the main troughs which run the whole length of the cooler; from these, gutters branch off, into which gas tubes are inserted, from which the water falls in jets on to splash plates, which give a splendid distribution of the water over the cooling hurdles. There are twenty of these hurdles, consisting of triangular laths laid into notches in the lath carriers. They work on the splash and surface principle of cooling water, and in such a manner that not only the maximum surface is exposed to the uprising air but also so much free area is left that the draught is not throttled, nor does the air, thanks to the splashplates, find a greater resistance at the level of the troughs. The total fall of the water is 26 ft. from ground level.

In spite of the massiveness of the construction, the cooler gives a very pleasing appearance, and, as far as we know, is unique in this country, although we understand that Messrs. Balcke have supplied several of these brick towers — some even of considerably larger dimensions—on the continent. Brick construction is certainly dearer than the standard wooden structure, but its life is practically unlimited, and the depreciation therefore very little.

Construction of a Spark Coil.*— Owing to the growing importance of the gas engine, the subject of spark coils for ignition purposes is becoming one of considerable interest. The general principles of induction coils are generally quite well understood, but if an amateur undertook to build a spark coil without a precedent, he would meet with many difficulties. The illustration on page 414 shows an auto-coil in section and side elevation, end view, top view and component parts in detail.

In order to build a coil such as that shown, procure some No. 18 annealed iron wire and cut off sufficient 5 $\frac{3}{16}$ in. lengths to fill a fibre tube of $\frac{3}{8}$ in. inside diameter. File off the ends square and solder a plate of copper on one end not over $\frac{1}{64}$ in. thick, the purpose of which is to keep the vibrator from sticking, due to residual magnetism in the core.

On the fibre sleeve wind two layers of No. 12 double-covered magnet wire and encase the whole in a glass insulating tube of $1\frac{1}{4}$ in. inside diameter. The thickness of the glass tube is not important, but a tube $\frac{1}{8}$ in. thick or more is advisable. Since the glass tube insulates the primary from the secondary coil, its mission is important.

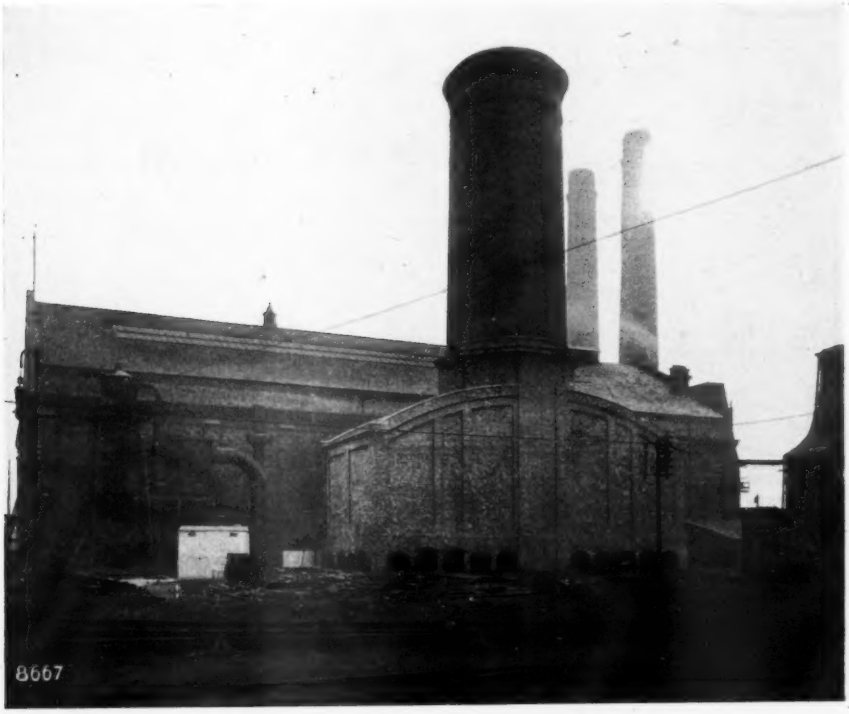
The secondary coil is wound with No. 36 silk double-covered magnet wire, which should be of the best quality; for if the insulation is defective the coil will be useless. Before winding have a ladle of melted paraffin at hand and a brush. Wind one layer of the wire on the glass tube, starting the winding about $\frac{1}{4}$ in. from the end of the tube and discontinuing $\frac{1}{4}$ in. from the opposite; then brush on hot paraffin and cover with an envelope of paper.

* *Electrical World*, N.Y.

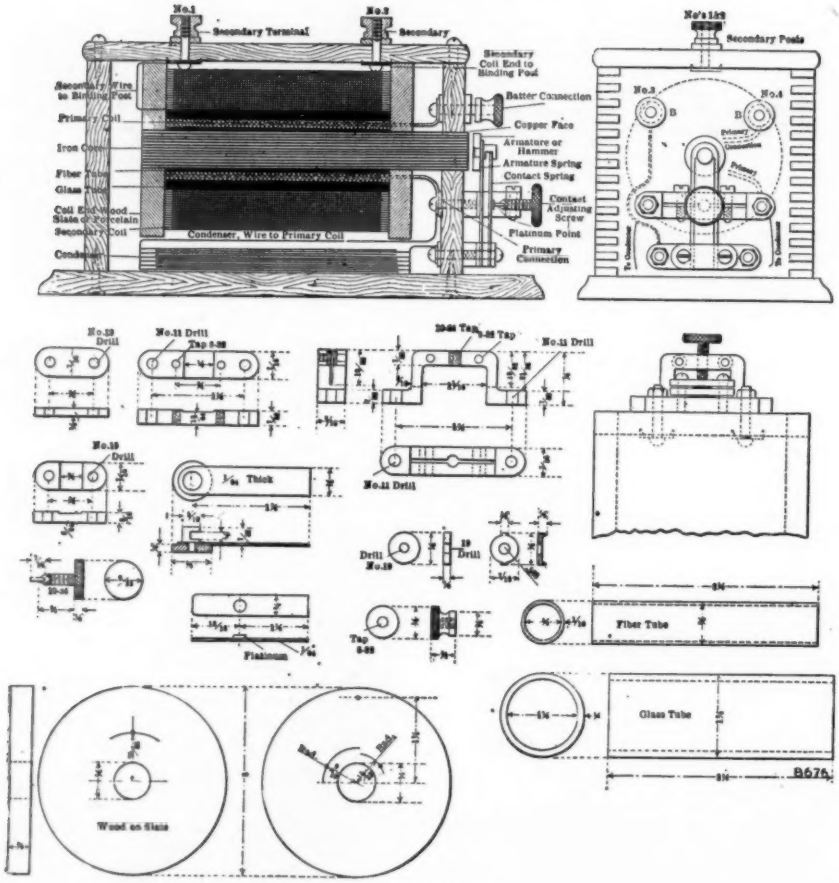
The paper should be fairly thick and of a quality that will absorb hot paraffin readily. Return the wire to the paper envelope and wind another layer of wire, starting ¼ in. from the end and stopping ¼ in. at the opposite end. Continue this process, layer by layer, coating each time with paraffin and a layer of paper, until the coil is of the proper size. The secondary terminals should be on opposite ends, and both primary terminals on the same end. When the coil is completed, soak it in very hot melted paraffin for an hour, and then let the coil cool in the paraffin until the latter has a mushy consistency, when the coil should be removed and the surplus of paraffin wiped off. The coil head may be made of wood, fibre, slate or porcelain; fibre will be entirely suitable.

For the condenser, procure a strip of paper 4 in. wide and about 120 in. long, and cut 40 sheets of tin foil 2½ in. wide by 4 in. long. Fold the paper strip 2⅝ in. wide and lay in a sheet of foil, leaving the end protruding $\frac{3}{10}$ of an inch; fold again and put in another sheet of the foil, allowing the end to protrude on the opposite end of the paper, and continue this process until 40 sheets of foil are used up. When finished there will be 20 sheets on each end to connect to. As the tin foil is too delicate for soldering, the connection may be made by forcing a wire against the ends of the foil. The several parts when finished are connected according to the accompanying drawing. Then pour melted paraffin in the box until the coil is submerged; allow this to set and then fill the shrinkage. Place the condenser in position, make the condenser connections and then fill the case entirely full with paraffin; smooth off and put on the bottom of case and the coil is complete.

The Institution of Civil Engineers' New Premises.—To authorise the sale to the Government of the present premises of the Institution of Civil Engineers, a special general meeting was recently held. The President (Sir



NATURAL DRAUGHT BRICK CHIMNEY COOLING TOWER. CENTRAL LONDON RAILWAY POWER STATION. SHEPHERD'S BUSH.



DETAILS OF AUTO-COIL

William Matthews) referred to the three years' confidential negotiations that had been going on between the Council and the Government Office of Works. The site decided upon in Great George Street was the accepted one. The proposed great hall would serve for special gatherings, examinations, and engineering conferences. The area of the new site is about 17,000 sq. ft., against 10,700 sq. ft. which is the area of the present premises. The Government are to pay £40,000 in cash for the latter, and also give an option to purchase No. 6, Great George Street, at £14,400. The final adjustment of payments will be at the rate of £8 5s. per square foot. The new premises can be built to a height of 70 ft., and about two years are allowed for their erection. Improvements will be made in the reading-room, the conversation-room, and the library.

Sir John Wolfe-Barry proposed the resolution increasing the members' entrance fee to twenty guineas, and the transfer fee from associate membership to full membership to ten guineas. He said he was in the position of the Chancellor of the Exchequer when he brings in a Budget to add something to the income-tax. The Institution would receive from the Government, in value of land and money, £93 000. The present building cost £62,000, and it was proposed to spend about £110,000 on the new premises. Provision for £85,000 had to be faced, and a net £1,000 a year more revenue would be required to meet the new conditions. Both resolutions were carried.

The Engineer's Book-shelf

Steam-Electric Power Plants. A Practical Treatise on the Design of Central Light and Power Stations and their Economical Construction and Operation. By FRANK KOESTER. (London: Archibald Constable & Co., Ltd.) 1908. Pp. xi. + 455. Price **21s.** net.

The author, who is well known as a contributor to the technical press and to technical societies on both sides of the Atlantic, has from his wide experience with the design and operation of steam-electric plants imparted much useful information on modern power plant practice in a comprehensive and useful volume. Its value is enhanced by the number of well executed line drawings and folding-in plates, while the half tones are clear and well printed. The subject is treated from the point of view of the designer, although the scope of the treatise does not include the design of machinery such as boilers, turbines, generators, &c. The range of subject matter will be indicated by an enumeration of some of the chapter divisions which include, I. Efficiency and Cost of Plants; II. Location, General Lay Out, Coal Storage, Condensed Water Supply; III. Building Structural Steel and Architectural Features; IV. Steam Raising and Apparatus pertaining thereto; V. Piping: VI. Prime Movers, Pumping Machinery and Oiling Systems; VII. Electrical Equipment: VIII Design of Small Plants: IX. Testing Power Plants; X. and XI. Typical American and European Light. The author has succeeded in making his subject interesting and his facts and information are well up-to-date. The work contains a number of valuable tables and it certainly appeals to a wider audience than to that interested purely in power-station design. We should have expected the chapter on testing power plants to have been developed in greater detail and to contain information of a more practical nature from the operating point of view; as it is the treatment is virtually limited to results of tests carried out on various plants. The electrical side of the subject is not treated in such detail nor so well as the mechanical and we confess that it is somewhat disappointing to find that practically only one short chapter is devoted to this important branch.

Structural Engineering. By A. W. BRIGHTMORE, D.Sc., M.Inst.C.E. (London: Cassell & Co., Ltd.) 1908. Pp. xv. + 276. Price **10s. 6d.** net.

The author has provided a text book the want of which has long been felt. How many students have discovered that from the strength of materials to specialised works such as Fidler on Bridge Construction, is indeed a long jump, and have met with difficulty in fully understanding the intermediate steps which underlie the investigations necessary in the design of structures. The author has filled this gap in an efficient manner. The scope of the text book includes the treatment of the following: Bending Moments and Shearing Forces; The Equilibrium Polygon; Braced Girders; Cross Sectional Area of the Members of a Structure; Stresses on Planes through a Point in a Member; Beams and Girders with solid Webbs; Continuous Girders and Cantilever Bridges; Deflection of Girders; Arches and Suspension Bridges; Reinforced Concrete Structures, &c. As the work is clearly written and no very advanced mathematics are used it will doubtless be cordially received by students and all interested in the design of structures.

The Calculus for Engineers. Integration and Differentiation with Applications to Technical Problems and Classified Reference Tables and Methods of Integration. By ROBT. H. SMITH, A.M.Inst.C.E., M.I.Mech. E., M.I.E.E. Second Edition. (London: Charles Griffin & Co., Ltd.) 1908. Pp. x. + 207. Price **7s. 6d.** net.

There is no royal road to the calculus, but this work, the second edition of which has just made its appearance, has earned for itself a widespread reputation as affording an easy and rapid method of acquiring power to apply, correctly and safely, the higher mathematics to technical problems. It shares with Prof. Perry's treatise the honour of being adopted by most engineering students and with the considerable additions made in the second edition, its utility is even more apparent. The new portions deal for the most part with applications—the original work of the author—to specially important technical problems, particularly those relating to economy in construction. Additions are also made to the reference tables of the integrals.

Machine Design, Construction and Drawing. By HENRY J. SPOONER. M.I. Mech.E., A.M.Inst.C.E., &c. With 86 tables and over 1,400 figures. (London: Longmans, Green & Co.) 1908. Pp. xxxii. + 691. Price **10s. 6d.** net.

This is a welcome volume as it is right up-to date, and while traversing the same ground as

do many well-known books on the subject, the author has chosen modern examples and arrangements. Specially useful chapters are those devoted to roller and ball bearings, friction gearing, wire-rope gearing, steel and iron tanks, machine handles and machine frames, a consideration of which is not usually found in books of this class. In matters relating to design and construction, most of the parts and details are shown with suitable proportions for various sizes, or are fully dimensioned with the object of making them useful to the young designer or fit for drawing exercises. We should like to see in books of this class, however, the names of *all* the details and parts stated fully on the drawing or referred to by lettering. This would not only give the student much useful information but exercise him in the use of correct technical terminology. The author has done better than many others in this respect but there is still much to be desired in this direction. Interesting exercises are given in Chapter XXXII. suitable for more advanced students consisting of full working drawings of a boiler feed pump and of a 20 h.p. marine petrol motor. The consideration of such a point as the design of machine frames is to be commended and the subject does not usually receive the attention it deserves. We could hope that the author had dealt with it even more fully than he has, as, particularly in the case of machine tools, very many advances have been made in the design of frames. The drawings are clear and well executed and in spite of the large number of pages the book is not cumbersome. Probably no better work could be found as a stepping stone to Unwin.

Practical Induction Coil Construction. By JOHN PIKE. (London: Percival Marshall & Co.) 1908. Price **1s.** net.

The subject matter of this book first appeared in the pages of the *Model Engineer*, and forms a useful guide to the building of a "spark coil."

The Motor Car and its Engine. A Practical Treatise for Motor Engineers—including Owners and Chauffeurs. By JOHN BATEY. (London: T. Fisher Unwin.) 1908. Pp. xxvi. + 290. Price **5s.** net.

This handy little volume has much useful information comprised within its 260 pages. It is not a pocket book, but deals in a readable and simple form with the chief problems involved in the action and running of the motor engine, including such points as adiabatic compression and expansion, heat transmission, balancing, and effect of reciprocating parts. The little work will do much to render an intelligent understanding of the more abstruse problems connected with the motor engine, possible to users and drivers who possess but scanty engineering knowledge. The engineer may find it disappointing, but we shall not find fault with it on that account—the volume is not intended for him. It is well printed but the total absence of illustrations will render the proper understanding of the text somewhat more difficult than might otherwise have been the case.

TRADE LITERATURE.

Lancaster & Tonge, Ltd., Pendleton, Manchester. Latest catalogue of the "Lancaster" Patent Steam Trap and Steam Dryers. Attention is drawn to the fact that since the issue of the last catalogue the firm's steam traps have been fitted to both the new Cunarders, the SSs. *Lusitania* and *Mauretania*. At the end of the catalogue is shown an engine, the cylinders of which are drained by "Lancaster" traps in such a manner that the rate of condensation in each cylinder can be ascertained at any time. This will no doubt prove a great boon to users who are troubled with very wet steam, as it will enable them to ascertain the amount of water in the steam at any time. **Alfred Herbert, Ltd.,** Coventry. 17th Edition of Section E catalogue, illustrating and describing the firm's Capstan Lathes. A feature of this list is that all the standard tools which are suitable for these machines are described and illustrated, thus enabling manufacturers to decide on an equipment suited to their particular methods of operation. Also Section A catalogue of horizontal and vertical milling machines. **Cochran & Co.,** Annan. Pamphlet descriptive of a model "Cochran" boiler arranged to show its construction and advantages. The letterpress is cast in interview form, which, combined with the admirable illustrations, forms an unique feature in catalogue literature. **Wilfley Mining Machinery Co., Ltd.,** Salisbury House, E.C. Comprehensive catalogue covering practically every branch of equipment required in the winning and treatment of minerals. **Hudson Economiser Co.** (1907), **Ltd.,** 2, Bishopsgate Street Without, E.C. Catalogue 'B' of the "Hudson" system of water-cooling. **T. A. Savery & Co.,** Birmingham. Catalogue of quick-revolution steam launch engines and boilers. **Carrick & Ritchie,** Edinburgh. Catalogue of Turbines, Pelton wheels and other water motors. **R. L. Ross & Co., Ltd.,** Stockport. Pamphlet on Automatic Lubrication with semi-solid lubricants. **Midgley & Sutcliffe,** Bradford. Sectional catalogue of plain milling and universal machines and radial drills. **Electric Tramway Equipment Co.,** Birmingham. Catalogue of scales and weighing machines. **Maschinen-fabrik Oerlikon,** 35, Norfolk Street, Strand. Periodical Communication, No. 42, L'installation de compensation des lamineries de Sandviken. **Siemens-Schuckertwerke,** Berlin. Pamphlets A. B. 16 & 17. Einachsige Drehgestelle für Strassenbahnwagen and Die umkehrbare Batteriezusatzmaschine "Bauart Pirani."

Machinery, Appliances and Processes.

The Editor invites advance particulars, drawings, blue prints, photographs, and any data that will enable him to publish an adequate description in these columns of any new work, machinery, or installation, possessing special features of interest. The cost of publication and engraving is borne by us, and no compensation is expected. In the endeavour to produce a really high-class and technically valuable machinery section the Editor seeks the co-operation of engineers and manufacturers.

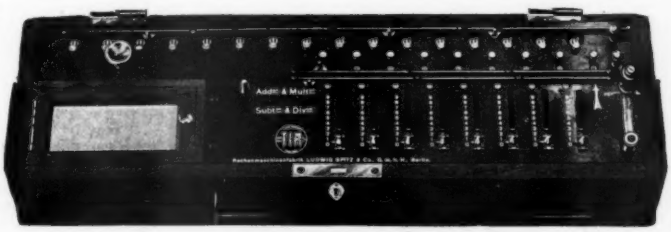
The "Unitas" Calculating Machine.

The history of the calculating machine dates back to the 17th century, for it was during the years 1672—1676 that the celebrated scientist, Liebnitz, constructed the first practical calculating machine, which is in existence at the present time. For a long time afterwards the invention of Liebnitz remained unrecognised, partly, perhaps, from inability to appreciate its possibilities, partly, too, because commercial and industrial activities had not in those days assumed anything like the importance which they do at the present time, and their utility was not so apparent as they are to-day.

It remained for Prof. Reuleaux, in his interesting brochure, "The so-called Thomas Calculating Machine," to give due recognition to the importance and value of Liebnitz's invention, and to the fact that it was he who had been the first to construct a really reliable and usable reckoning machine.

Numerous inventors have from time to time produced and invented machines of greater or less excellence with various technical improvements, many of them workable practical instruments with which all calculations involving the application of the four principal arithmetical rules may be accurately and rapidly performed, and enabling the users to adapt and apply them to their various requirements, but it has remained for a German engineer, Ludwig Spitz, to construct and perfect what is perhaps the most useful of all modern calculating machines. Ludwig Spitz has introduced an entirely new feature into the manufacture of these instruments, by the addition of a second slide or carriage, which may be used either in connection with the ordinary machine or disconnected from it, and thereby calculations of distinctly opposite character may be performed simultaneously, as, for example, multiplication and subtraction, division and multiplication, or addition and subtraction. It need not be urged that such a feature alone adds immensely to the potentialities of the machine, and renders possible the production of sub-totals and grand totals automatically and simultaneously, or grand totals, percentage or discount and remainder at the same time.

A view of the machine with the double



SINGLE-SLIDE CALCULATING MACHINE.

slide for effecting these operations is shown in the accompanying illustration; a machine, however, for those whose operations are comprised within the first four rules only is made in which the top slide is dispensed with.

Some idea of the method of operation may be obtained by taking a simple example in addition. The machine having been brought to zero by the shift levers seen on the extreme right of the central portion of the apparatus, the markers on the lower or keyplate are placed to indicate the figures to be added, the units in the first groove on the right, tens in the second, and so on. The large handle in the bottom right-hand corner is then turned through one revolution, whereupon these figures appear on the lower indicators in the central slide. The markers on the key-plate are now placed opposite the figures representing the item to be added, and upon making another revolution with the large handle, the total of the two items appears in the top line of indicators in the central slide. This operation is repeated until all the items have been added.

Multiplication is merely continued addition, as $25 \times 3 = 25 + 25 + 25 = 75$. For example, $534 \times 26 = 13{,}884$, the first factor is registered on the key-plate by the markers as explained above, and the large handle is turned as many times as the value of the unit of the other factor, in this case six times. In the first small indicator there appears the number 6, which shows that the factor 534 has been added six times or multiplied by six. In the larger indicators above the product of 534×6 appears, viz., 3,204. By means of the handle seen to the left, the middle slide is shifted one place to the right, and the large handle to the right is then turned as many times as the value of the figure in the tens of the other factor, in this case twice, the result being that the factor 534 is twice added or multiplied by 2. The lower indicators now show 26, the multiplier, and the upper indicators of the central slide the product of $534 \times 26 = 13{,}884$. It will thus be seen that the manipulation of the instrument is a simple matter, a very short time sufficing to enable a complete grasp of the principles underlying its action to be obtained. It may be mentioned that the top slide and upper row of indicators are used for obtaining grand totals, &c., whilst the subsidiary operations are being performed with the central slide. One other feature of the machine should be mentioned—it is almost noiseless in action. The calculations possible with the "Unitas" should cause it to find favour in engineering establishments, it being specially adapted for the following: Checking accounts, as each extension and the grand total is shown at the same time. If discounts are to be taken off, the machine will show at the same time grand total, percentage, discount, and remainder. In calculating deductions on a bill, the amount deducted and the remainder are shown in one operation. For figuring time-sheets and pay-rolls; in computing cost of manufacturing, the machine checks itself automatically in pro-rating and dividing.

If desired, the machine will accumulate the total of all the items making up total cost of manufacturing, which, divided by the total of output, will show the total of percentages. It is being exploited by the Pin and Unitas Calculating Machine Co., Bond Street, W.

Pump Pressure Regulators.

At the recent engineering exhibition at Olympia there were on view at the stand of Messrs. The Crosby Steam Gage and Valve Co. of 147, Queen Victoria Street, E.C., several pressure controlling devices by the Mason Regulator Co., of Boston, U.S.A., who make a considerable variety of this class of apparatus.

Brief reference only was made to this exhibit at the time, but we are now able to give some fuller details and illustrations. One of these appliances is a pump pressure regulator illustrated in Figs. 1 and 2. It is of the spring type and is placed in the steam supply pipe to the pump which it is required to regulate, and connected by a $\frac{1}{4}$ in. pipe to the delivery system. It is suitable only for a supply pipe of 2 in. diameter downwards; for larger sizes the lever type illustrated in Fig. 3, is called for. The action of the apparatus is as follows:—

Steam from boiler enters at point marked, "steam inlet from boiler," and thence through passage *X*, through the port, which is kept open by tension of the spring 83 upon auxiliary valve 80. It continues down through passage *N* to under side of differential piston 70 and raises valve 16 so that boiler pressure is admitted to the pump through passage marked "steam outlet to pump."

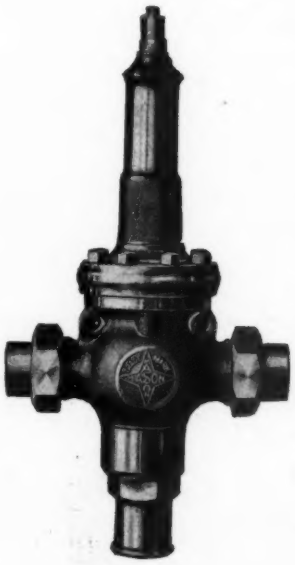


FIG. 1.

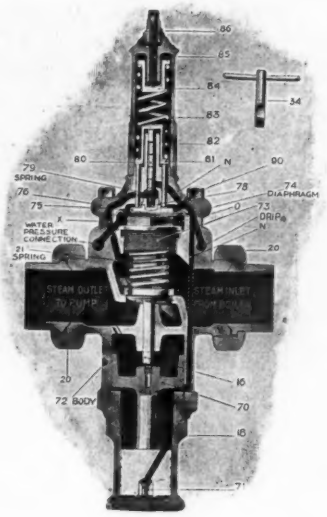


FIG. 2.

This starts the pump, which continues in motion until the required water pressure is obtained in the system and acts on diaphragm 74, through connection marked "water pressure connection." This diaphragm is raised by excess of water pressure, and carries with it auxiliary valve 80, which closes the port for steam pressure. By the closing of this valve, the boiler pressure is shut off through passage *N* from differential piston 70 and steam pressure from the boiler immediately closes main valve 16 so that no more steam is admitted to the pump. The pump remains inactive until the water pressure in the system drops below the normal point and relieves the water pressure in the chamber which causes auxiliary valve 80 to open again and start the pump as before described. Check valve 71, which is placed in bottom of the piston 70, allows the pressure regulator to open easily, but stops the pump quickly. This is a great advantage, as the instant the water drops, the pump will not start with a jump. By changing the tension of spring 83 through key stem 85, the amount of water pressure which it is desired to carry in the system can at any time be changed or regulated.

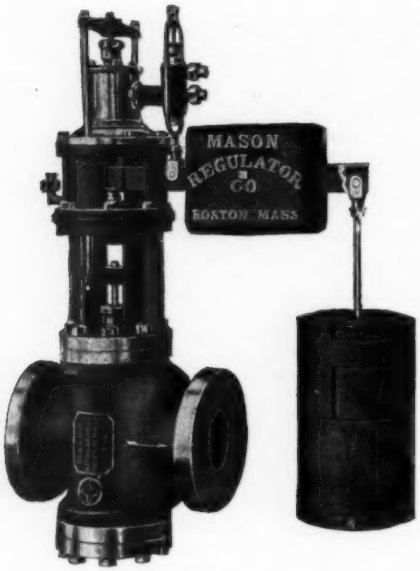


FIG. 3.

In the lever type apparatus referred to above, and illustrated in Fig. 3, a weighted lever, suspended on hardened steel knife edges, is in contact with a heavy rubber diaphragm. A connection is made from the delivery system to the under side of the diaphragm. Sufficient weights having been fitted to balance the desired pressure any excess of pressure under the diaphragm causes an upward movement of the lever, thus actuating a pilot valve attached to a small operating cylinder above. This pilot valve is also connected with the delivery pressure, and on its being moved upwards admits water pressure to the operating cylinder, the piston of which is connected by means of a crosshead to the main steam valve below, thereby positively closing it. On the pressure being relieved the lever falls, and the movement of the pilot valve first opens to exhaust and then admits water pressure to the other side of the operating piston, thereby positively opening the main valve.

The last illustration (Fig. 4) is that of a horizontal pressure controlling device. This is made with various sizes of diaphragms suitable for vacuums, low pressures and for pressures up to 400 lbs., also with cup leather packed plunger for pressures up to 3,000 lbs.

This pressure controller, as shown, makes a complete stroke with a slight change of the controlling pressure; but where a graduated step by step movement is required, as for operating an electric rheostat, the controller is fitted with a compensating attachment. To obtain a definite variation in pressure between stopping and starting a variating attachment is fitted, and where a continuous slow movement in one direction is required with normal speed on the return stroke, a slowing attachment is fitted.

It should be mentioned that the Crosby Gage and Valve Co. act as agents for the makers in this country.

FIG. 4.

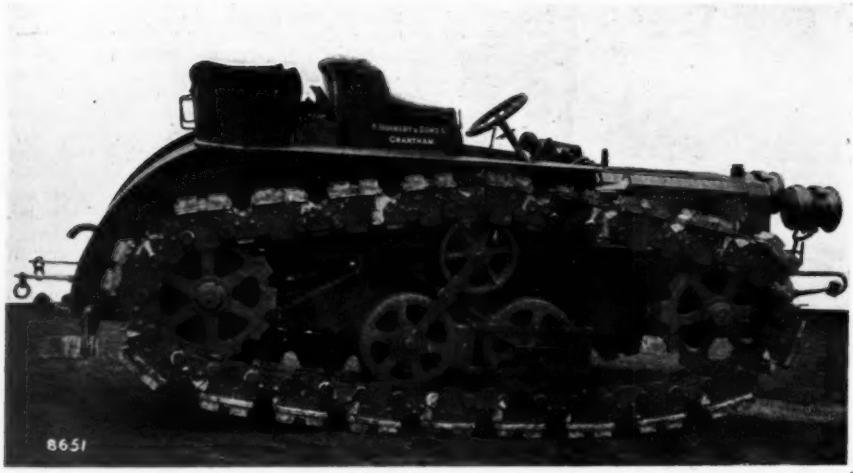
A Chain Track Tractor.

Many attempts have been made from time to time to design a tractor which will travel with certainty and safety over loose, soft or uneven ground, traverse ditches or generally negotiate such country as is impassable for traction engines of the ordinary type. Some success was achieved with the "Rail-Ring" tractor and by Mr. Diplock's "Pedrail" machine a year or two back, and duly noticed in these columns at the time: a further step has, however, been made by Messrs. Hornsby & Sons, Ltd., Grantham, who have introduced a system which bids fair to establish itself as a solution of the problem. The invention of Mr. David Roberts, M.I.Mech.E., the managing director of the firm, the new tractor is the outcome of prolonged study and experiments in order to meet the further requirements of the War Office, and it has undergone tests by that authority the results of which have, we are informed, exceeded their expectations.

Prolonged tests have also been conducted by Messrs. Hornsby, which seem to prove that the new Chain Track system fulfills all the requirements for service in undeveloped regions. On swampy ground a lurry loaded with three tons was hauled by five horses until it sank to the axles, when the horses failed to drag it out. The 30-35-h.p. motor car model, weighing 3 tons 15 cwt., and hauling a trailer loaded with 5 tons, and equipped with the chain track in lieu of wheels, then proceeded to travel over the same ground, and negotiated it successfully. Horses were subsequently harnessed to the car itself, and succeeded in dragging it across the test ground, notwithstanding the fact that they had failed with the lurry, and also with a two-wheeled cart carrying 1½ tons.

As a test of its hill-climbing capacity, the Chain-Track tractor showed itself to be capable of surmounting a bank of soft clay 20 ft. high, having an incline of 1 in 2. It has also been driven up an incline of 1 in 10, the surface of which was covered in ice 1 in. in thickness. Spikes, sand and gravel were necessary to obtain adhesion for the tread of the chain, but the ice itself was unbroken.

25 H.P. OIL TRACTOR WITH CHAIN TRACK.



HORNSBY 35 H.P. CHAIN TRACTOR WITH CAR BODY.

The tractor is designed to transport heavy loads, at minimum cost and risk, where no roads or railways are available, and where the only transport at present is by ordinary wheeled vehicles, the use of which is so costly and precarious as to be almost prohibitive, or by animal transport.

The system is essentially an endless chain, the inside of which forms a track on which the weight-carrying wheels move. The chain is formed of a number of "feet" linked together with an intermediate locking arrangement so that it is flexible for movement round its axes but rigid towards the resistance of the road. It therefore presents to the road surface a rigid arc. Within the chain are several wheels. The middle wheels (generally two) are the weight-carrying wheels, running on the track formed by the inside of the rigidly linked feet. The back wheel is the power wheel, the sprockets of which engage the inside of the links. On power being applied this wheel pulls at a chain, but the latter being held firmly by the weight of the engine the effect of the pull is to roll the engine along the track, and as this is done the feet are released and carried over the sprocket wheel and forward over the top of the chain to the front to form a fresh and endless track. Generally more than one of the feet are in contact with the road, but in soft ground the number of feet in contact is increased according to the depth to which the ground yields. A ditch is bridged by the bottom arc of the chain, or the engine descends at one bank and rises at the other. During severe trials one of these tractors scaled a bank of soft clay, 1 in 2, and about 12 ft. high, and afterwards drew up its load on a wagon fitted with a chain track. In a morass where carts or trolleys

TRACTOR GOING UP A SAND BANK WHICH A STEAM TRACTION ENGINE HAS BEEN UNABLE TO NEGOTIATE.

become hopelessly bogged, the chain tractor will haul its load with perfect ease. Of the tractors at present constructed, one is driven by a 30-35 h.p. internal combustion engine, and another by an oil engine of 20 h.p., but the system may be adapted to any kind of motive power, as well as to any class of vehicle.

HEAVY OIL TRACTOR NEGOTIATING A DITCH.

Rotary Box-Making Machine.

Although the box-making machinery is somewhat wide of the ordinary scope of this journal, an exception may be made in the case of a new and ingenious machine, the invention of Mr. A. W. Mitchell, forming the subject of the half-tone on p. 424.

In this machine, which is completely automatic in its action, the reciprocating principle hitherto used in this class of machinery has been abandoned in favour of the rotary principle, with the result that the speed of production of the boxes hitherto obtainable has been greatly increased, and that without unfavourably affecting the character of the work; in fact a superior product has been rendered possible by the new machine.

On the occasion of our visit the machine was at work making shot-shell double cartridge boxes, 4 in. by 4 in. by 2⅜ in., at the rate of 100 complete boxes per minute. When it is remembered that 27 per minute represents the maximum output of the class of machine using dies and plungers, the practical value of the invention will be clearly appreciated. Moreover, waste is practically eliminated in the process of manufacture by this machine.

Although the particular machine illustrated has been designed to make one class and size of box only, namely the cartridge box mentioned above, the fundamental features of the design admit of a ready and adequate extension to include the manufacture of practically any class of cardboard box, and moreover in a range of sizes within the limits usually required in actual practice. For example six sizes differing in dimensions of about 2 in. cover practically all the requirements of the boot trade. The action of the machine is briefly as follows:—

The machine is fed from a roll of cardboard, the subsequent operations comprising in succession, glueing, scoring, cutting, folding up the sides, folding up the ends and stripping the finished box from the plunger.

The feed roll of cardboard is carried on a shaft and held in position thereon by two flanged cones, one of which is adjustable along the axis of the shaft to suit the gauge of the card employed, which in turn depends upon the size of box to be made. The web first passes to the glueing roll by which those portions of the card which are subsequently required to adhere are glued without smudging, by an ingenious arrangement of pads, which are alternately raised and depressed during one revolution of the glueing roller by an interior cam mechanism. The cardboard web, having been glued, passes through a guide in which clearance spaces are left to permit the free passage of the glued surfaces, to the top surface of the table, where it travels forward, held in position by guides.

The web is then scored by being passed beneath a pair of scoring cutters carried on a shaft, the inside cutter being adjustable laterally to correspond with the size of box that is being made. Movement of the cardboard along the machine is by a pair of feed rollers through which the web next passes. These rolls feed the cardboard forward intermittently for a distance equal to the length of the blank required for a complete box, this intermittent motion being conveyed to these rollers by a Geneva stop motion. The cardboard web is next passed through a pair of cutting rollers which notch the opposite edges of the web to shape. The lower of these rollers is fitted with knives which are adjustable; hence, one roller only suffices for the various re-settings: the top cutting roller, however, being shaped to

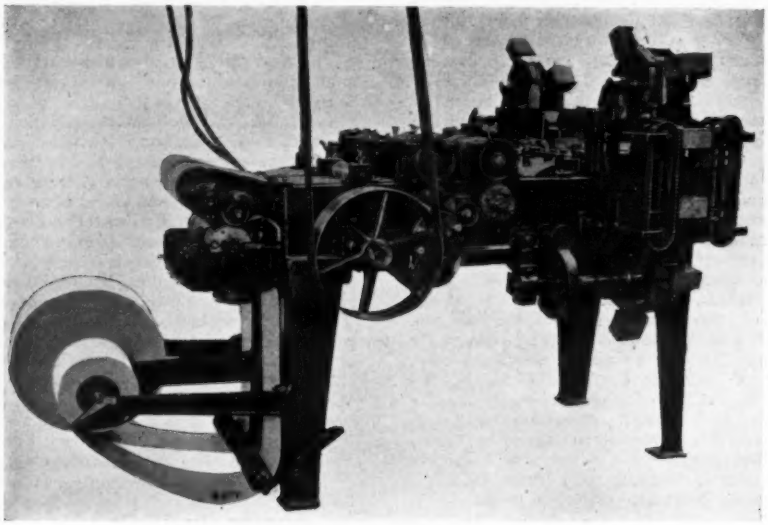
suit each size of box made, a corresponding number of rolls are required.

The board thus glued, scored, and notched to shape, passes to a folding guide to have the sides folded up along the longitudinal lines put in by the scoring cutters. This consists of two side guides and a central wedge-shaped guide suspended from a yoke, the latter being of sufficient over-all dimensions to admit the widest cardboard used on the machine. Adjustment for smaller sizes is thus confined to the inner side guide and the removal and replacing of the central wedge, which is grooved on its under side for clearance of the glued lines on the surface of the paper.

Having thus had its sides folded, the blank is severed by a cutter from the web and is next presented to a stationary guide where one of the plungers of an endless chain of plungers is brought down on to the blank, and at the same time fingers fold up the flaps of the sides over the ends of the plunger, and then the end flaps are folded up over these side flaps as the plunger carries the blank through the die. As the inner faces of these flaps are glued they are caused to adhere.

The blanks are carried by the plungers right through the die to emerge as finished box bodies or covers. A simple apparatus carried on a pair of endless chains suffices to strip the finished box body.

The machine promises to result in a considerable alteration of existing methods of manufacture, and should secure to users of boxes in large quantities a considerable diminution in the cost of production. It is being exploited by the Rotary Box Machine Syndicate, Ltd., Aldermanbury, E.C.



ROTARY BOX-MAKING MACHINE.

In this section is presented every month a list of the more important articles appearing in the Engineering Press and of the leading papers read before the various engineering institutions. Full names, addresses, and published prices of the publications indexed are printed each half-year in the volume index.

Civil Engineering.

Reinforced Concrete Sea Defences (*concluded*). By H. Huisman. *Concrete and Constructional Engineering, May*, 1908.

The Concrete Sea-Wall at Cebus, Philippine Islands. By H. F. Cameron. *Engineering Record, 25th April*, 1908.

Erection of French River Bridge—Canadian Pacific Railway. By C. N. Monsarrat. *Transactions Canadian Society Civil Engineers, April*, 1908.

The Overturned Caisson of the Baltimore Lighthouse. *Engineering, 8th May*, 1908.

Structural Steelwork (*continued*). By E. G. Beck. *Mechanical World, 8th May*, 1908.

Pontoon or Floating Drawbridges. *Engineering News, 30th April*, 1908.

The Theory of Lattice Columns: A Comparison of Cantilever Bridge Chords, and a Discussion of the Quebec Bridge Specifications. *Engineering News, 30th April*, 1908.

Erection of Bridges, X. *Railway Engineer, May*, 1908.

Masonry Dam Formulas. By C. La Brodie. *School of Mines Quarterly, April*, 1908.

A German Railway Viaduct of Cantilever Construction with Novel Hinge Detail. *Engineering News, 23rd April*, 1908.

The Semi-circular Masonry Arch. By A. E. Lindau. *Proceedings American Society Civil Engineers, April*, 1908.

Spirally Armoured Concrete Piles, *Engineer, 8th May*, 1908.

The Cataract Dam, Sydney, N.S.W. *Engineering, 24th April*, 1908; *Engineer, 24th April*, 1908.

The Erection of the Manhattan Bridge Towers, *Engineering Record, 4th April*, 1908; *Engineering News, 16th April*, 1908.

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Projected Tunnel under the Great Belt.

A Danish engineer—Mr. H. Ohrt—has prepared plans for a tunnel under the Great Belt, on which he recently lectured before the Industrial Society, Copenhagen, several members of the Danish Parliament being present. The increasing railway traffic made, in the speaker's opinion, a tunnel under the Great Belt, between the island of Zealand and Fuhnen, a necessity. The tunnel, according to the present plan, would follow a straight line, proceeding from Svenstrup, in Zealand, passing under the Island of Sprogö to the coast of Fuhnen. The distance under the Belt is about 11½ miles, in addition to which there would be 1½ miles of tunnel on the Zealand side, and 1¼ miles on the Fuhnen side. The gradient suggested is 1 : 60, which is not excessive. The Great Belt tunnel would have to descend to a depth of 31 fathoms at one spot, but, on the other hand, there would be no great changes in the temperature, which would remain at some 7° C. Mr. Ohrt holds that the tunnel in all places should be at least 66 ft. (20 metres) beneath the bottom of the Belt. From the deepest point, about three miles off the Zealand Coast, the tunnel would rise slowly to a depth of 150 ft. beneath the Island of Sprogö, where there would be a shaft for ventilation. From Sprogö the tunnel is to proceed in level line to close to the Fuhnen Coast, where the ascending gradient will be 1 : 100, whilst it would be 1 : 60 on the Zealand side. The tunnel will have to be lined, preferably with granite. The duration of the work is calculated at four to five years. The cost, of course, would be great and the contingencies to be faced would be very considerable. The risks of subaqueous borings are enormous, and cannot be foreseen. The late Mr. T. A. Walker, speaking of the Severn Tunnel, for which he was the contractor, said that one such enterprise was enough for a lifetime.—*Engineering*.

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